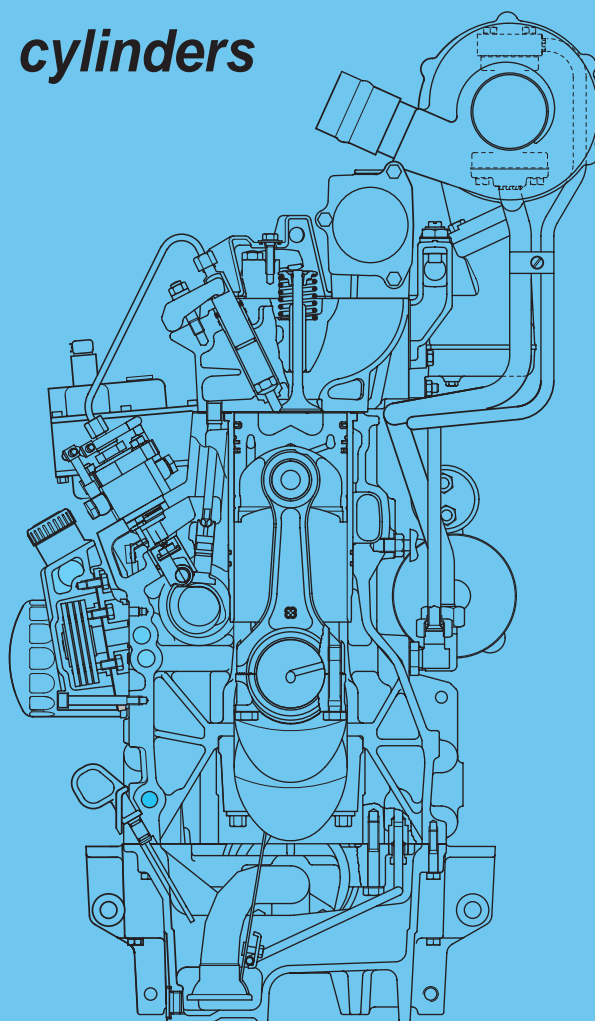
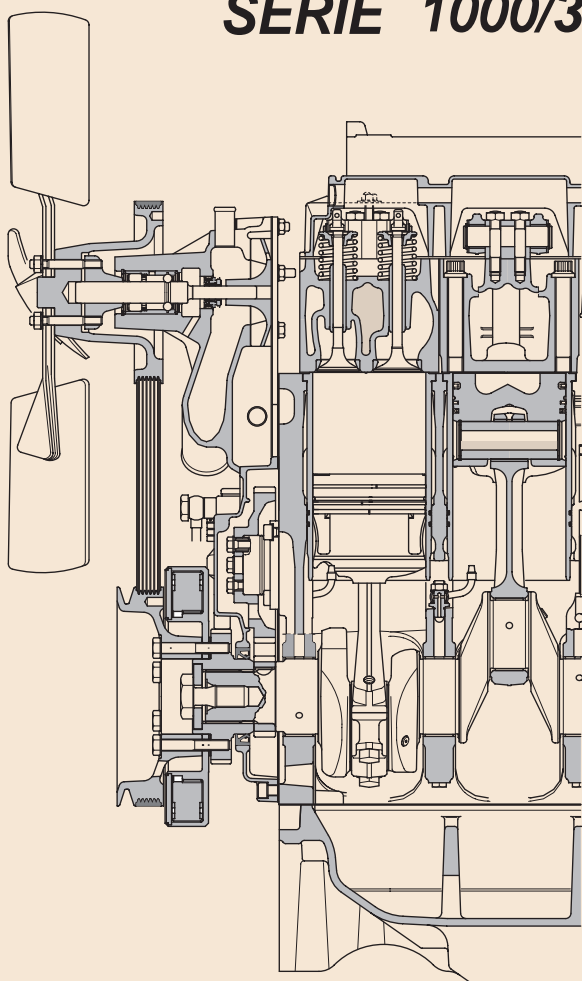




SAME DEUTZ-FAHR  
ITALIA S.p.A:

# *ENGINE* **EURO 2**

**SERIE 1000/3-4-6 cylinders**



# **WORKSHOP MANUAL**



# CONTENTS

<b>IMPORTANT PRELIMINARY INFORMATION.....</b>	<b>1</b>		
<b>HOW TO CONSULT THE MANUAL.....</b>	<b>3</b>		
<b>HOW TO USE AND UPDATE THE MANUAL .....</b>	<b>4</b>		
<b>LIFTING INSTRUCTIONS.....</b>	<b>5</b>		
<b>STANDARD TIGHTENING TORQUES FOR NUTS AND BOLTS .....</b>	<b>6</b>		
<b>THREADLOCKERS, ADHESIVES, SEALANTS AND LUBRICANTS.....</b>	<b>7</b>		
<b>SPECIAL TOOLS .....</b>	<b>9</b>		
<b>CONVERSION FACTORS .....</b>	<b>10</b>		
<b>ENGINE TYPE IDENTIFICATION AND SERIAL NUMBERS.....</b>	<b>11</b>		
<b>IDENTIFICATION OF INJECTORS AND INJECTION PUMPS .....</b>	<b>13</b>		
<b>DETERMINING THE INJECTION ADVANCE ANGLE .....</b>	<b>14</b>		
 <b>ENGINE DISASSEMBLY</b>			
<b>1. PRELIMINARY REMOVAL OPERATIONS .....</b>	<b>15</b>		
<b>2. REMOVAL OF THE COOLING AND INTAKE PIPES .....</b>	<b>18</b>		
<b>3. REMOVAL OF THE CYLINDER HEADS .....</b>	<b>20</b>		
• 3.1 Dismantling the cylinder heads .....	28		
• 3.2 Dismantling the rocker arm supports .....	29		
<b>4. REMOVAL AND TESTING OF THE THERMOSTATS.....</b>	<b>30</b>		
• 4.1 REMOVAL .....	30		
• 4.2 TESTING THE THERMOSTATS .....	31		
<b>5. REMOVAL OF THE COOLANT PUMP .....</b>	<b>32</b>		
• 5.1 3- AND 4-CYLINDER VERSIONS.....	32		
• 5.2 6-CYLINDER VERSIONS.....	32		
<b>6. REMOVAL OF THE UNIT PUMPS, ACTUATOR AND FUEL LIFT PUMP .....</b>	<b>33</b>		
<b>7. OVERHAUL OF THE MECHANICAL GOVERNOR DRIVE.....</b>	<b>38</b>		
• 7.1 DISASSEMBLY .....	38		
• 7.2 ASSEMBLY .....	40		
<b>8. OVERHAUL OF THE MECHANICAL GOVERNOR (STANDARD AND WITH L.D.A.) .....</b>	<b>44</b>		
• 8.1. DISASSEMBLY OF THE STANDARD GOVERNOR .....	44		
• 8.1.1 Separation of the lower and upper housings .....	44		
• 8.1.2 Assembly of the lower housing.....	49		
• 8.1.3 Adjusting the height of the lever control bush.....	50		
• 8.1.5 Assembly of the upper housing .....	54		
• 8.1.6 Assembly of the governor housing ..	54		
• 8.2 DISASSEMBLY OF THE GOVERNOR WITH L.D.A. VALVE.....	55		
• 8.2.1 Separating the upper and lower housings .....	55		
• 8.2.2 Renewal of the membrane.....	56		
• 8.2.3 Completion of the disassembly .....	57		
• 8.2.4 Assembly of the governor with L.D.A. valve.....	59		
• 8.3 BENCH ADJUSTMENT OF L.D.A. VALVE.....	61		
• 8.3.1 Adjusting the length of the tie-rod ...	61		
• 8.3.2 Adjusting the spring load .....	61		
• 8.3.3 Adjusting the membrane travel.....	62		
• 8.4 FINAL ADJUSTMENTS .....	62		
• 8.4.1 Adjusting the fuel flow rate .....	62		
• 8.4.2 Calibration for mechanical governors.....	63		
• 8.4.3 Adjusting the maximum speed .....	64		
• 8.4.4 Hunting adjustment.....	64		
• 8.4.5 Adjusting the idle speed .....	65		
• 8.4.6 Sealing the governor.....	65		
<b>9. ADJUSTMENT OF THE ELECTRONIC ACTUATOR.....</b>	<b>66</b>		
• 9.1 CALIBRATION OF ELECTRONIC ACTUATORS.....	67		
<b>10. REMOVAL OF THE INJECTION PUMP CONTROL ROD .....</b>	<b>68</b>		
<b>11. REMOVAL AND DISASSEMBLY OF THE HEAT EXCHANGER (For 4- and 6-cylinder versions) .....</b>	<b>69</b>		
<b>12. DISMANTLING THE VALVE TIMING DRIVE .....</b>	<b>70</b>		
<b>13. DISMANTLING THE CRANKSHAFT .....</b>	<b>73</b>		
• 13.1 REMOVAL OF THE HARMONIC BALANCER (4-cylinder versions when fitted) .....	75		
• 13.2 OVERHAUL OF THE HARMONIC BALANCER (when fitted).....	75		
• 13.2.1 Disassembly .....	75		
• 13.2.2 Assembly .....	76		
• 13.3 REMOVAL OF THE CRANKSHAFT .....	76		
• 13.4 DISMANTLING THE OIL PUMP .....	79		
• 13.4.1 3- and 4-cylinder versions .....	79		
• 13.4.2 6-cylinder version.....	80		

<b>14. REMOVAL OF THE PISTONS AND CYLINDER LINERS .....</b>	<b>81</b>
• 14.1 SEPARATING THE PISTON-CONNECTING ROD ASSEMBLY .....	81
<b>15. RENEWAL OF THE REAR CRANKSHAFT OIL SEAL .....</b>	<b>83</b>
<b>16. TESTS - TECHNICAL DATA AND DIMENSIONS.....</b>	<b>84</b>
• 16.1 CYLINDER HEADS - VALVES - ROCKER ASSEMBLIES.....	84
• • 16.1.1 Inspection and renewal of valve guides.....	84
• • 16.1.2 Renewal of the valve guides .....	84
• • 16.1.3 Inspecting the valve seats.....	84
• • 16.1.4 Inspecting the valves.....	85
• • 16.1.5 Inspecting the valve springs.....	85
• • 16.1.6 Testing the valve seals .....	86
• • 16.1.7 Checking injector protrusion .....	86
• • 16.1.8 Renewal of the copper bushes .....	87
• • 16.1.9 Inspecting the rocker arms and pivot posts.....	87
• • CYLINDER HEADS - VALVE GUIDES - VALVE SEATS .....	88
• • VALVES - VALVE SPRINGS .....	89
• • ROCKER ARMS - ROCKER PIVOT POSTS - TAPPETS.....	90
• 16.2 INJECTORS - INJECTION PUMPS .....	91
• • 16.2.1 Testing the injectors.....	91
• • INJECTOR TECHNICAL DATA - NATURALLY ASPIRATED ENGINES.....	92
• CALIBRATION METHOD .....	93
• • INJECTOR TECHNICAL DATA - TURBOCHARGED ENGINES .....	94
• • INJECTOR TECHNICAL DATA - INTERCOOLER ENGINES .....	96
• 16.3 PISTONS - CONNECTING RODS .....	98
• • 16.3.1 Inspection of the pistons and piston rings.....	98
• • 16.3.2 Inspecting the connecting rods - gudgeon pins .....	99
• 16.4 INSPECTION OF THE BIG-END CAP BOLTS100	
• • PISTONS code 0.013.1456.0 (3-4-6 cylinder W engines) .....	101
• • PISTON RINGS .....	101
• • PISTONS code 0.012.8912.0 ( 3- cylinder WT engines).....	102
• • PISTON RINGS .....	102
• • PISTONS code 0.012.8913.0 ( 4-6 cylinder WT engines).....	103
• • PISTON RINGS .....	103
• • PISTONS code 0.012.8483.4/20 (4-6 cylinder WTI engines).....	104
• • PISTON RINGS .....	104
• • CONNECTING RODS (FOR PISTONS W-WT).....	105
• • CONNECTING RODS (FOR PISTONS WTI).....	106
• 16.5 CRANKSHAFT .....	107
• • CRANKSHAFT (3-CYLINDER VERSION) ..	109
• • CRANKSHAFT (4-CYLINDER VERSION) ..	110
• • CRANKSHAFT (6-CYLINDER VERSION) ..	111

• 16.6 ENGINE BLOCK - CYLINDER LINERS .....	112
• • 16.6.1 Engine block.....	112
• • 16.6.2 Inspection of the cylinder liners.....	112
• • ENGINE BLOCK - CYLINDERS.....	114
• 16.7 CAMSHAFT .....	115
• • CAMSHAFT (13° STATIC ADVANCE).....	116
• • CAMSHAFT (16° STATIC ADVANCE).....	117
• 16.8 TIMING GEARS .....	118
• • 16.8.1 Removal of the gear shaft .....	118
• • TIMING GEARS .....	119
• 16.9 HARMONIC BALANCER (For 4 cylinder engines only).....	120
• • HARMONIC BALANCER .....	121
• 16.10 FLYWHEEL.....	122

## ENGINE ASSEMBLY

<b>17. FITTING THE PISTON COOLING NOZZLES.....</b>	<b>123</b>
<b>18. FITTING THE CYLINDER LINERS, PISTONS AND CONNECTING RODS.....</b>	<b>124</b>
<b>19. FITTING THE CAMSHAFT-CRANKSHAFT AND CONNECTING ROD BIG-ENDS.....</b>	<b>126</b>
<b>20. ASSEMBLY OF THE HARMONIC BALANCER (For 4-cylinder engines only, only when fitted) ....</b>	<b>130</b>
<b>21. REFITTING THE OIL PUMP - SUMP PAN.....</b>	<b>131</b>
• 21.1 3- AND 4-CYLINDER VERSIONS.....	131
• 21.2 6-CYLINDER VERSION .....	131
• 21.3 ASSEMBLY OF THE ENGINE OIL SUMP ....	132
<b>22. CALCULATING THE THICKNESSES OF THE HEAD GASKETS AND REFITTING THE CYLINDERHEADS .....</b>	<b>133</b>
<b>23. REFITTING THE CYLINDER HEADS .....</b>	<b>134</b>
<b>24. REFITTING THE INJECTION PUMP CONTROL ROD .....</b>	<b>136</b>
<b>25. REFITTING THE MECHANICAL GOVERNOR DRIVE AND THE ELECTRONIC GOVERNOR SUPPORT .</b>	<b>137</b>
<b>26. ADJUSTMENT OF THE TIMING GEARS.....</b>	<b>138</b>
<b>27. VALVE TIMING.....</b>	<b>140</b>
• 27.1 Checking the camshaft timing.....	141
<b>28. TIMING THE INJECTION PUMPS .....</b>	<b>142</b>
<b>29. REFITTING THE ROCKER ASSEMBLIES .....</b>	<b>147</b>
<b>30. ADJUSTMENT OF VALVE CLEARANCES - INJECTOR ASSEMBLY .....</b>	<b>148</b>
• 30.1 Valve clearance adjustment .....	148
• 30.2 Injector assembly .....	148
<b>31. FINAL ENGINE ASSEMBLY OPERATIONS .....</b>	<b>149</b>
<b>32. FINAL ENGINE ASSEMBLY - REAR END.....</b>	<b>161</b>
<b>33. ENGINE TESTS.....</b>	<b>164</b>
• 33.1 Initial start-up and oil pressure check .....	164
• 33.2 Synchronizing the injection pumps. ....	165
• • 33.2.1 Test.....	165
• • 33.2.2 Angular adjustment of the injection pumps .....	165



# IMPORTANT PRELIMINARY INFORMATION...


**⚠** For reasons of clarity, the illustrations in this manual show the engine and its components with safety guards and covers removed, and do not contain any specific indications regarding the safety precautions to be taken; in addition to normal safety precautions and good working practices, it is important to observe the general rules given here below.

- During disassembly and assembly operations, observe all the safety and accident prevention measures prescribed by EEC Directives; in particular, do not use improvised or worn tools, wear fuel and oil resistant gloves, do not allow any spilt oil or grease to remain on the floor - clean it up straight away, wear suitable clothing, shoes with non-slip soles, etc.
- If splashed with oil or fuel, change your clothing and wash thoroughly any contaminated parts of the body.
- Dispose of all lubricants, fuel, gaskets, oil seals and any other items considered as special waste in a proper manner in accordance with the applicable regulations.
- The disassembly, assembly and inspection operations described in this manual refer to engines that have been removed from the vehicle and/or industrial assembly and mounted on a suitable engine stand.
- Before fixing the engine to the stand, ensure that all apertures (intake, exhaust, turbocharger, air compressor, fuel and oil filler holes, etc.) are covered and clean the engine thoroughly. Use steam or pressurized hot water for general cleaning and then paraffin or degreasing agents to remove any particularly stubborn dirt.  
After cleaning, dry the engine with a low-pressure air jet (2-3 bar) and protect all machined parts with a thin film of lubricant or anti-corrosion product.
- Before fixing the engine to the stand, remove all accessories that could prevent fixing to the stand and those which would be impossible to remove once the engine is mounted on the stand (flexible coupling, starter motor, flywheel, flywheel cover, fan, rear oil seal).
- The disassembly and assembly operations described in this manual refer to a 4-cylinder engine; except for the specific shape and dimensions of a few external parts (e.g., rocker covers, inlet and exhaust manifolds, fans, etc.) and the presence of certain internal assemblies (e.g. harmonic balancer), the instructions given apply to all versions.  
Any differences regarding calibration data or parts are indicated with the notes «For versions with..... cylinders only» or «W - WT - WTI versions».
- The engine type codes indicate:  
W =water cooled  
T = turbocharger  
I = Intercooler  
N° = engine version
- Before disassembly of engines for overhaul of the injection pump, injectors or cams, first determine the basic technical data (engine type, serial number, injection pump type, injector type, static injection advance angle) by following the procedures indicated in the first pages of this manual and referring to the section «TECHNICAL DATA AND DIMENSIONS».


**PAGE INTENTIONALLY  
LEFT BLANK**

# HOW TO CONSULT THE MANUAL

## 1. Removal and refitting of assembled units


- (1) For the removal or refitting of assembled units, the sequence of operations and the methods to be applied are described in the removal procedure; if the refitting sequence of operations is the exact reverse of the removal procedure, it is not described.
- (2) All special techniques that apply only to the refitting procedure are indicated by the symbol ; this same symbol appears at the end of each major step in the removal procedure to indicate the parts for which special techniques are to be applied during refitting.


E.g.: **REMOVAL OF UNIT:**..... Operation heading

 : ..... Safety rules to be observed when carrying out the procedure described

1 - Remove part (1): ..... Step of the procedure

★: ..... Technique or important information regarding the removal operation.

2 - Disconnect (2).....  : ..... Indicates the existence of special information regarding refitting of the component in question.


 ..... ℓ: ..... Recover oil, liquid or fuel and the quantity to be recovered

E.g.: **REFITTING UNIT:** ..... Operation heading

- Refitting is the reverse of removal

 : ..... Technique to be applied during refitting


★: ..... Technique or important information regarding the refitting operation

•  ..... ℓ: ..... Filling with oil or liquid with quantity

## 2. List of special tools

- (1) For details regarding the type, code numbers and quantity of all the tools (T1, T2, etc.) specified in the operating procedures, see the heading «SPECIAL TOOLS».

## 3. Tightening torques

- 1 - In the operating procedures, the symbol  denotes a specific tightening torque that has been determined experimentally and that must be adhered to.
- 2 - If the symbol does not appear, the torque values to be used are those indicated in the table in Section 00 of this manual.

# HOW TO USE AND UPDATE THE MANUAL

## 1. UPDATING THE MANUAL

All additions, corrections or amendments to the manual will be sent to the Authorised Service Centres.

Before starting any repair or overhaul operations, check that you have the most recent updates as these may contain supplementary data not present in previous issues.

## 2. INSERTING UPDATES

1- **Check** the number of the page and insert it in the appropriate section of the manual following the consecutive order of the page numbers.

2 - **Supplementary pages:** indicated with a hyphen (-) and consecutive number after the page number. Example:

5  
 5-1  
 5-2  
 6

} Supplementary page

**NOTE. The contents of supplementary pages are structured so that there is no overlap with existing pages.**





3 - **Updated pages:** indicated by a consecutive number in a circle; this symbol appears below the page number. Example:





5  
 5-1 – Existing page  
 5-1 – Update page  
 ①  
 5-2 – Existing page

**NOTE. All supplementary and updated pages are indicated in the manual page list; a revised page list is sent with each update and supersedes the previous list.**

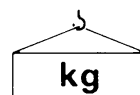
## 3. SYMBOLS USED IN THE MANUAL

For greater clarity, important information pertaining to operator safety and to critical stages in the working procedures is highlighted by the symbols shown in the following table.


Symbol	Meaning	Notes
	Safety	Safety rules to be applied during operation.
		Operation requiring special safety measures due to internal pressure.
	Warning	Operations requiring special technical or other precautions to ensure compliance with standard values.
	Weight	Weight of main assemblies. Choose lifting ropes/slides carefully; supports required, etc.

Symbol	Meaning	Notes
	Coating	Parts must be coated with adhesive, lubricant, etc.
	Oil, water	Points at which oil, water or fuel must be added and quantity required.
	Drain	Points from which oil, water or fuel must be drained with quantity.
	Tightening torques	Parts requiring special tightening torque during refitting or assembly.

# LIFTING INSTRUCTIONS










**!** Components weighing over 25 kg or of significant size must be supported and removed using suitable lifting equipment with wire rope or polyester slings.

In the paragraphs regarding removal and refitting operations, the weight of the component or assembly to be lifted is indicated with the symbol .

## WIRE ROPES - SLINGS

- Use wire ropes or polyester slings of suitable capacity for the parts to be lifted, referring to the following tables:

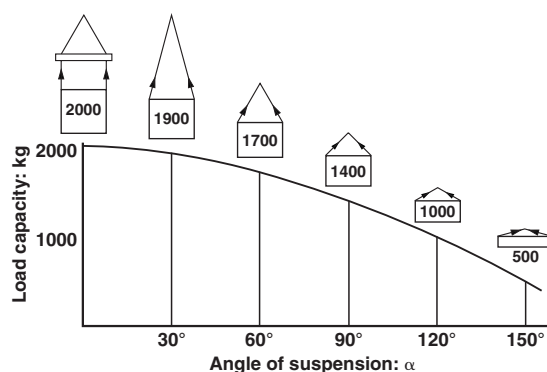
WIRE ROPES (standard twisted «S» or «Z» type)				POLYESTER SLINGS (eye-and-eye - simple loop)				
Ø rope mm	Capacity (kg)			Width (mm)	Capacity (kg)			
								
8	650	620	500	25	500	400	860	700
10	1000	1740	1420	50	1000	800	1730	1410
12	1450	2500	2050	62	1250	1000	2160	1760
14	2000	3460	2820	75	1400	1120	2420	1980
16	2600	4500	3670	100	2000	1600	3460	2820
18	3300	5710	4660	150	2500	2000	4330	3530

**NOTE. Lifting capacities are calculated with a safety coefficient.**

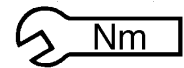
- The lifting hook should be attached to the central part of the rope or sling; if the hook is attached near the ends of the rope/sling, this could cause the load to slip during lifting.
- Never lift a heavy load using a single rope; always use two or more symmetrically arranged ropes.

**!** Suspension of a load from a single rope could cause the load to start rotating and consequently cause the rope strands to untwist or the load to slip; this could lead to serious injury.

- Never lift a heavy load when the two branches of the ropes form a wide angle.  
The permitted load (kg) decreases in inverse proportion to the angle of suspension; the table below indicates how the permitted load varies according to the angle of suspension for two Ø 10 mm ropes each with a load capacity of 1000 kg.



# STANDARD TIGHTENING TORQUES FOR NUTS AND BOLTS



The tightening torques for certain specific components and special tightening methods are indicated in the relative assembly paragraphs.



The tightening torques indicated below refer to bolts and nuts assembled without lubrication and, where applicable, with anaerobic threadlocking compound.

The values apply to tightening on steel or cast iron components; for soft materials such as aluminium, copper, plastic, sheet metal or panels, the indicated tightening torques must be reduced by 50%.

BOLT SIZE		BOLT CLASS					
		8.8		10.9		12.9	
		Nm	lb.ft.	Nm	lb.ft.	Nm	lb.ft.
COARSE THREAD	M6x1	8.0 – 8.8	5.9 – 6.5	11.8 – 13.0	8.7 – 9.6	13.8 – 15.2	10.2 – 11.2
	M8x1.25	19.4 – 21.4	14.3 – 15.8	28.5 – 31.5	21.0 – 23.2	33.3 – 36.9	24.5 – 27.2
	M10x1.5	38.4 – 42.4	28.3 – 31.2	56.4 – 62.4	41.6 – 46.0	67.4 – 74.4	49.7 – 54.8
	M12x1.75	66.5 – 73.5	49.0 – 54.2	96.9 – 107	71.4 – 78.9	115 – 128	84.8 – 94.3
	M14x2	106 – 117	78.1 – 86.2	156 – 172	115.0 – 126.8	184 – 204	135.6 – 150.3
	M16x2	164 – 182	120.9 – 134.1	241 – 267	117.6 – 196.8	282 – 312	207.8 – 229.9
	M18x2.5	228 – 252	168.0 – 185.7	334 – 370	246.2 – 272.7	391 – 432	288.2 – 318.4
	M20x2.5	321 – 355	236.6 – 261.6	472 – 522	347.9 – 384.7	553 – 611	407.6 – 450.3
	M22x2.5	441 – 487	325.0 – 358.9	647 – 715	476.8 – 527.0	751 – 830	553.5 – 611.7
	M24x3	553 – 611	407.6 – 450.3	812 – 898	598.4 – 661.8	950 – 1050	700.2 – 773.9
	M27x3	816 – 902	601.4 – 664.8	1198 – 1324	882.9 – 975.8	1419 – 1569	1045.8 – 1156.4
FINE THREAD	M8x1	20.8 – 23.0	15.3 – 17.0	30.6 – 33.8	22.6 – 24.9	35.8 – 39.6	26.4 – 29.2
	M10x1.25	40.6 – 44.8	29.9 – 33.0	59.7 – 65.9	44.0 – 48.6	71.2 – 78.6	52.5 – 57.9
	M12x1.25	72.2 – 79.8	53.2 – 58.8	106 – 118	78.1 – 87.0	126 – 140	92.9 – 103.2
	M12x1.5	69.4 – 76.7	51.1 – 56.5	102 – 112	75.2 – 82.5	121 – 134	89.2 – 98.8
	M14x1.5	114 – 126	84.0 – 92.9	168 – 186	123.8 – 137.1	199 – 220	146.7 – 162.1
	M16x1.5	175 – 194	129 – 143	257 – 285	189.4 – 210.0	301 – 333	221.8 – 245.4
	M18x1.5	256 – 282	188.7 – 207.8	375 – 415	276.4 – 305.9	439 – 485	323.5 – 357.4
	M20x1.5	355 – 393	261.6 – 289.6	523 – 578	385.5 – 426.0	611 – 676	450.3 – 498.2
	M22x1.5	482 – 532	355.2 – 392.1	708 – 782	521.8 – 576.3	821 – 908	605.1 – 669.2
	M24x2	602 – 666	443.7 – 490.8	884 – 978	651.5 – 720.8	1035 – 1143	762.8 – 842.4

# THREADLOCKERS, ADHESIVES, SEALANTS AND LUBRICANTS



FUNCTION	DESIGNATION	DESCRIPTION
THREADLOCKER	<b>Loctite 222</b> Colour: opaque fluorescent purple	Anaerobic product suitable for low-strength locking of retaining, adjustment and precision fasteners. All traces of lubricant must first be removed using the specific activator.
	<b>Loctite 242</b> Colour: fluorescent blue	Anaerobic product that prevents loosening of all types of nut and bolt; used in place of conventional mechanical locking systems. Used for medium-strength locking. All traces of lubricant must first be removed using the specific activator.
	<b>Loctite 243</b> Colour: opaque fluorescent blue	Alternative product to 242; oil tolerant and so can be used on lightly lubricated surfaces without prior use of activator.
	<b>Loctite 270</b> Colour: fluorescent green	Anaerobic product for high-strength locking of bolts and studs that do not normally require disassembly. Parts must be heated to approximately 80°C for removal. All traces of lubricant must first be removed using the specific activator.
DEGREASERS AND ACTIVATORS	<b>Loctite 703</b>	Product used for degreasing and cleaning parts prior to application of Loctite anaerobic products; after drying, promotes uniform curing of threadlockers.
	<b>Loctite 747</b>	Product used specifically for treatment of passive metals prior to use of slow-cure anaerobic threadlockers (series 5 and 6). Can also be used to increase cure speed at low temperatures or in applications where there are large gaps between the parts.
SEALANTS (for faces and flanges)	<b>Loctite 510</b> Colour: red	Super-rapid anaerobic sealant for sealing between rigid metal faces; can eliminate the need for conventional gaskets as it can fill gaps up to 0.4 mm. Does not shrink and therefore fasteners do not need re-tightening to specified torque values after curing.
	<b>Loctite 542</b> Colour: brown	Anaerobic product used as a liquid sealant for threaded fittings up to 3/4" gas; rapid curing and parts may be disassembled with ordinary tools.
	<b>Loctite 554</b> Colour: red	Anaerobic sealant and locking compound used for sealing cooling and industrial fluid circuits. Slow curing, also suitable for use on non-ferrous alloys.
	<b>Loctite 572</b> Colour: white	Anaerobic sealant and locking compound used for sealing pipes and threaded fittings up to 2" in diameter. Very slow curing on most metal surfaces.
	<b>Loctite 573</b> Colour: green	Thixotropic anaerobic product used for sealing joints between metal faces. Ensures total contact between surfaces with maximum tolerance of 0.10 mm, filling microvoids caused by flatness errors. Very slow curing on most metal surfaces and requires prior application of an activator.
	<b>Loctite 576</b> Colour: brown	Anaerobic product used as a liquid thread sealant for large diameter threaded fittings (up to 2"). Very slow curing; also suitable for non-ferrous alloys and parts requiring subsequent removal.

## THREADLOCKERS, ADHESIVES, SEALANTS AND LUBRICANTS

FUNCTION	DESIGNATION	DESCRIPTION
INSTANT ADHESIVES	<b>Loctite 401</b> Colour: colourless	Cyanoacrylate instant adhesive suitable for bonding a wide range of acidic and porous materials including, ceramics, wood, rubber and plastic (excluding polyolefin). Curing takes place in a few seconds as an effect of the condensed humidity present on the surfaces to be bonded, and is independent of environmental conditions.
	<b>Loctite 495</b> Colour: colourless	Cyanoacrylate instant adhesive suitable for bonding a rubber, plastics and metal in any combination.
SILICONE SEALANTS	<b>Silastic 738 (Dow Corning)</b> Colour: milky white	One-part silicone adhesive/sealant, ready for use. Cures on exposure to air to form a rubbery solid and obviates the need for conventional seals on flexible joints, filling gaps greater than 1 mm.
	<b>Dirko Transparent</b> Colour: transparent	One-part silicone adhesive/sealant, shrinking, ready for use. Cures rapidly when exposed to humidity in the air to form a rubbery solid; resistant to high temperatures.
POLYURETHANE SEALANTS	<b>Betaseal HV3 (Gurit Essex)</b> Colour: black	Polyurethane prepolymer based adhesive/sealant, high viscosity, suitable for permanent, high-strength flexible bonding. Slow curing, used for bonding glass to frames, wire mesh, metal plates, etc. surfaces must be degreased with primer.
RETAINING COMPOUNDS	<b>Loctite 601</b> Colour: fluorescent green	Anaerobic, fast-curing, high-strength adhesive. Suitable for sealing and retaining cylindrical assemblies with gap clearances of up to 0.10 mm; used for retaining rotors, gears, bearings, pulleys, bushes etc. on shafts.
	<b>Loctite 638</b> Colour: fluorescent green	Anaerobic structural adhesive, quick-curing, very high strength; suitable for bonding cylindrical parts in non-ferrous alloys.
	<b>Loctite 648</b> Colour: fluorescent green	Anaerobic structural adhesive, quick-curing, high-strength; suitable for bonding cylindrical parts, permanent retention of threaded parts, sealing of refrigeration systems, retention of bearings, etc. Alternative to Loctite 601 in high-temperature applications.
	<b>Loctite 986/AVX</b> Colour: fluorescent red	Anaerobic sealant/retaining compound for metal cylindrical parts. Slow-curing, high-strength, heat-resistant and resistant to chemical pressure. Parts must be first treated with an activator.
LUBRICANTS	<b>Grease (NLGI 2 EP ASTM D217: 265/295)</b>	Multi-purpose Lithium grease used for lubrication of seals, to prevent oxidization and to facilitate assembly operations.
	<b>Molikote (Dow Corning)</b>	Anti-wear compound, contains Molybdenum bisulphate, use neat or diluted with engine oil for assembly of main engine bearings.
	<b>Vaseline</b>	Neutral pH compound used to protect battery terminals against oxidization and corrosion.
	<b>Engine oil 10W - 30</b>	Used to dilute Molikote anti-wear lubricant during assembly of main engine bearings.



## SPECIAL TOOLS

TOOL	CODE	DESCRIPTION	PAGE
<b>T1</b>	5.9030.433.0	Tool for measuring valve stand-in and cam protrusion	28-50-84-113
<b>T2</b>	5.9030.012.0	Valve spring compressor	28
<b>T3</b>	5.9030.020.0	Bore gauge for valve guides	84
<b>T4</b>	5.9030.665.0	Mechanical governor disassembly tool	44-46-50
<b>T5</b>	5.9030.967.0	Sleeve protrusion measuring tool for seals	133
<b>T6</b>	5.9030.885.0	L.D.A. valve centering tool	60
<b>T7</b>	5.9030.887.0	Governor drive gear installation tool	41
<b>T8</b>	5.9030.888.0	Angled gauge contact point for measuring gear backlash	43-130
<b>T9</b>	5.9030.850.0	Valve guide removal tool	84
<b>T10</b>	5.9030.852.0	Valve guide installation tool	84
<b>T11</b>	5.9030.651.4	Connecting rod square	99
<b>T12</b>	5.9030.008.4/10	Crankshaft gear puller	107
<b>T13</b>	5.9030.349.0	Cylinder bore hone	113
<b>T14</b>	5.9030.731.4	Oil jet installation tool (pistons without oil way)	123
	5.9030.732.4	Oil jet installation tool (pistons with oil way)	
<b>T15</b>	5.9030.654.0/10	Piston ring compressor	124
<b>T16</b>	5.9030.631.4/10	Cylinder liner clamping blocks	113-125-133
<b>T17</b>	5.9030.640.0	Angle tightening wrench	128-129-134
<b>T18</b>	5.9030.886.0	Dial gauge stand for measuring harmonic balancer end float	130
<b>T19</b>	5.9030.615.0	Dial gauge stand for engine timing	140-141-145
<b>T20</b>	5.9030.950.0	Injection pump timing tool	142
	5.9030.958.0	Measuring sleeve	
<b>T21</b>	5.9030.951.0	Injection pump locating dowel	143-144-146
<b>T22</b>	5.9030.960.0	Pump control rod alignment tool (for mechanical regulator)	143-145
	5.9030.959.0	Pump control rod alignment tool (for electronic regulator)	
<b>T23</b>	5.9030.634.0	Timing cover alignment tool	158
<b>T24</b>	5.9030.667.4	Digital thermometer	165
<b>T25</b>	5.9030.952.0	Spacer for engines with twin exhausts	154
<b>T26</b>	5.9030.953.0	Pump rotation tool	165-166

## CONVERSION FACTORS

### CONVERSION FROM BRITISH TO METRIC UNITS

inch x 25.40	= mm
foot x 0.305	= m
yard x 0.914	
Eng.miles x 1.609	= km
Sq.in. x 6.452	= cm <sup>2</sup>
Sq.ft. x 0.093	= m <sup>2</sup>
Sq.yard x 0.835	
Cu.in. x 16.39	= cm <sup>3</sup>
Cu.ft. x 28.36	= m <sup>3</sup>
Cu.yard x 0.763	
Imp.gall. x 4.547	= litres
US gall. x 3.785	
pint x 0.568	
quart x 1.137	
US.gpm x 3.785	= ℓ/min
oz. x 0.028	= kg
lb. x 0.454	
lb.ft. x 0.139	= kgm
lb.in. x 17.87	= kg/m
psi x 0.070	= kg/cm <sup>2</sup>
lb./Imp.gall x 0.100	= kg/ℓ
lb./US.gall x 0.120	
lb./cu.ft. x 16.21	= kg/m <sup>3</sup>
lb.ft. x 1.356	= Nm
psi x 1.379	= bar

### CONVERSION FROM METRIC TO BRITISH UNITS

mm x 0.0394	= inch
m x 3.281	= foot
m x 1.094	= yard
km x 0.622	= Eng.miles
cm <sup>2</sup> x 0.155	= Sq.in.
m <sup>2</sup> x 10.77	= Sq.ft.
m <sup>2</sup> x 1.197	= Sq.yard
cm <sup>3</sup> x 0.061	= Cu.in.
m <sup>3</sup> x 0.035	= Cu.ft
m <sup>3</sup> x 1.311	= Cu.yard
litres x 0.220	= Imp.gall.
litres x 0.264	= US gall.
litres x 1.762	= pint
litres x 0.880	= quart
ℓ/min x 0.2642	= US.gpm
kg x 35.25	= oz.
kg x 2.203	= lb.
kgm x 7.233	= lb.ft.
kg/m x 0.056	= lb.in.
kg/cm <sup>2</sup> x 14.22	= psi
kg/ℓ x 10.00	= lb./Imp.gal.
kg/ℓ x 8.333	= lb./US.gal.
kg/m <sup>3</sup> x 0.062	= lb./cu.ft.
Nm x 0.737	= lb.ft.
bar x 14.503	= psi

# ENGINE TYPE IDENTIFICATION AND SERIAL NUMBERS

**NOTE.** The terms **RIGHT** and **LEFT** refer to the engine as viewed from the timing end.

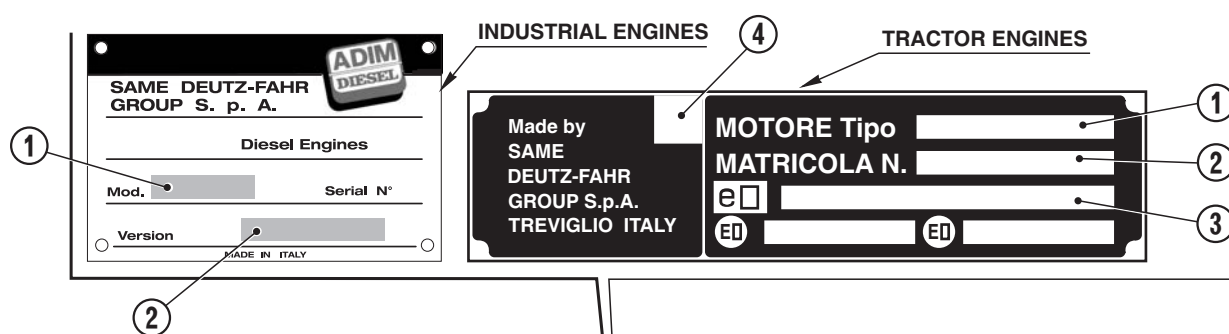
## 1. Europe version

The engine type and serial number (between the ☆ symbols) are indicated on the identification plate fixed to the right-hand side of the crankcase in the vicinity of the starter motor.

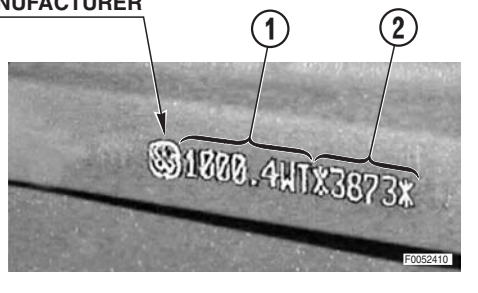
In addition to the Manufacturer's symbol, the identification plate contains:

- 1 - Engine type
- 2 - Serial N° (between the ☆ symbols)
- 3 - Type approval N°
- 4 - Injection advance

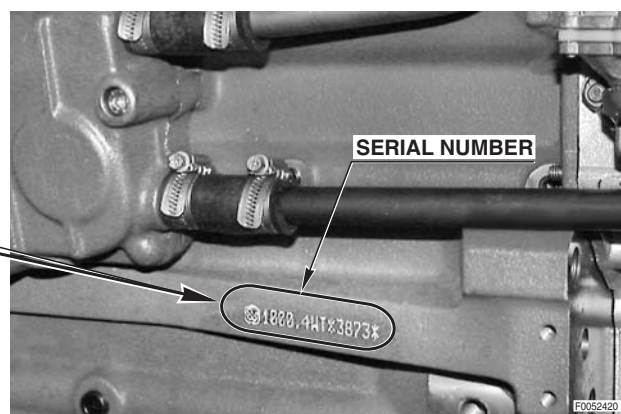
The serial n° (between the ☆ symbols) is also stamped on the left-hand side of the crankcase.



**MANUFACTURER**



**SERIAL NUMBER**



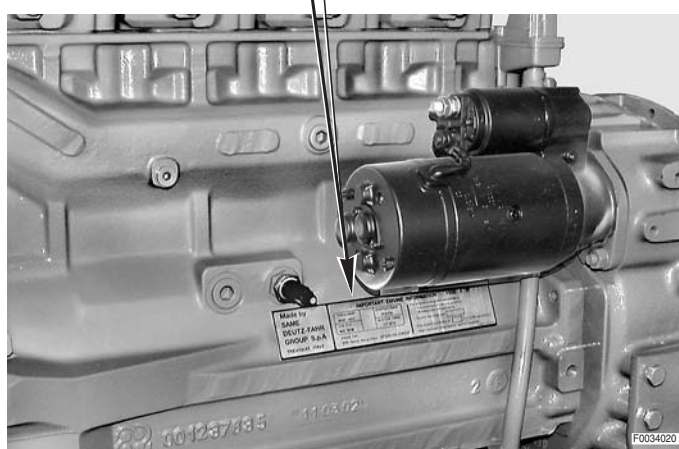
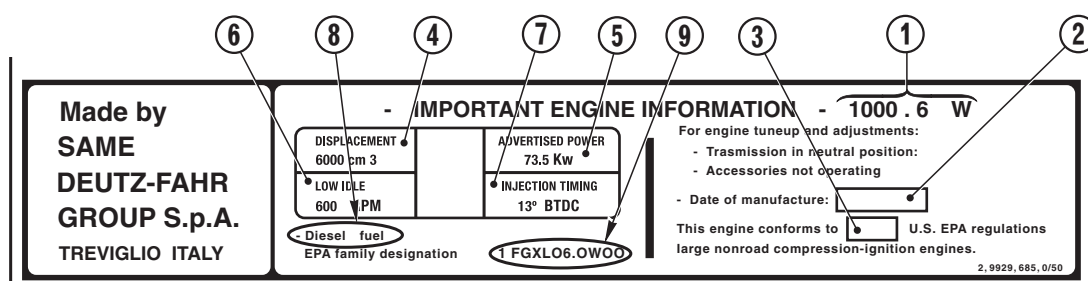
## 2. EPA Version

Engines destined for countries that require EPA homologation have a plate that contains, in addition to the name of the Manufacturer, the following information:

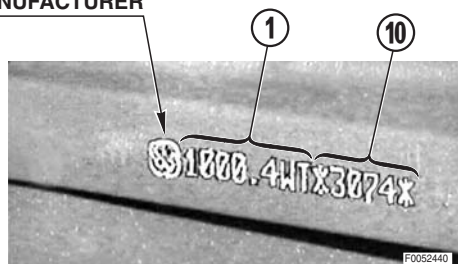
- 1 - Engine type
- 2 - Month and year of manufacture
- 3 - Number of the U.S. EPA regulation to which the engine conforms
- 4 - Engine displacement (cm<sup>3</sup>)
- 5 - Declared power (kW)
- 6 - Minimum idle speed (rpm)
- 7 - Injection advance angle (degrees)
- 8 - Type of fuel required
- 9 - Designation of the EPA class (the 1st digit refers to the year of manufacture)

On these engines the serial number (between the ☆ symbols) is stamped only **on the left-hand side of the crankcase**, while the identification plate is fixed to the right-hand side of the crankcase in the vicinity of the starter motor.

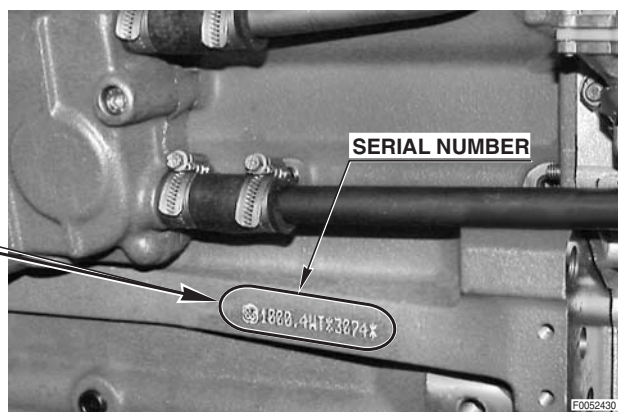
**NOTE.** The injection advance angle (BTDC) is also stamped on the left-hand side of the crankcase near the identification data.



MANUFACTURER



SERIAL NUMBER

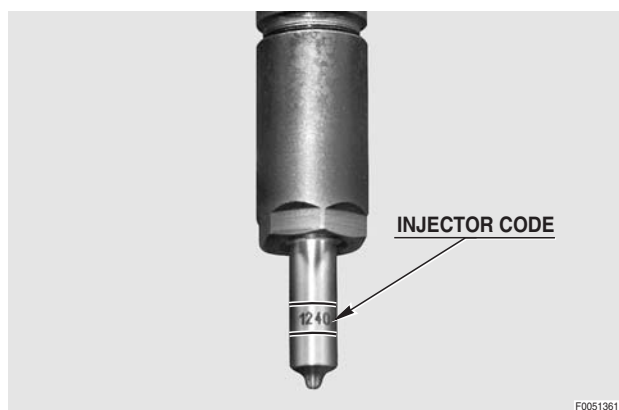


# IDENTIFICATION OF INJECTORS AND INJECTION PUMPS

## 1. INJECTORS

- 1 - Read off the numbers on the injector nozzle which represent the last part of the BOSCH code.
- 2 - Look for the injectors in the "TECHNICAL CHARACTERISTICS" section and for the corresponding ordering code in the table below.

Terminal code BOSCH	Code injector nozzle (BOSCH)	Ordering code injector nozzle	Complete injector code
1351	DLLA 150P 1351	2.4729.620.0	2.4719.630.0
1352	DLLA 150 1352	2.4729.630.0	2.4719.640.0
1240	DLLA 145P 1240	2.4729.490.0/10	2.4719.620.0



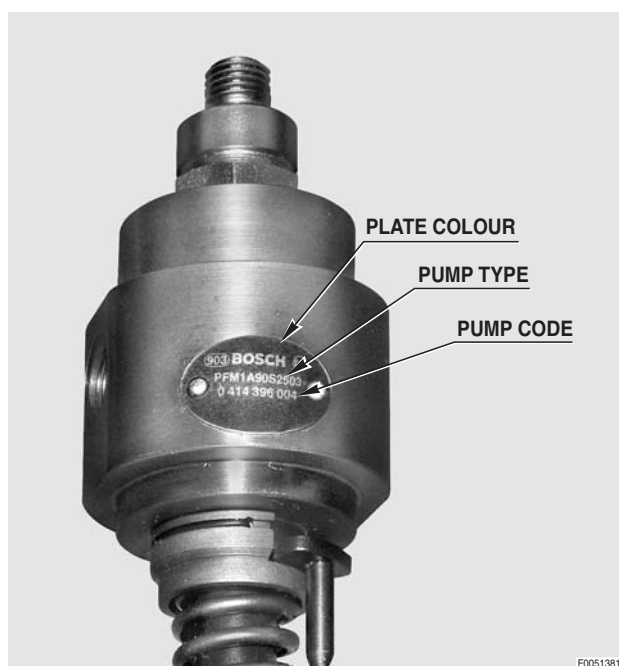
## 2. INJECTION PUMPS

- 1 - Make a note of the pump type and the BOSCH code indicated on the identification plate.
  - ★ If necessary, use a solvent to remove the layer of paint.

- 2 - Note the colour of the pump identification plate.

**⚠ Always quote all the above information when ordering.**

Plate colour	Pump type (BOSCH)	Pump code (BOSCH)	Ordering code complete pump
Green	PFM1A 90S 2504	0 414 396 005	2.4619.270.0
Blue	PFM1A 90S 2503	0 414 396 004	2.4619.190.0



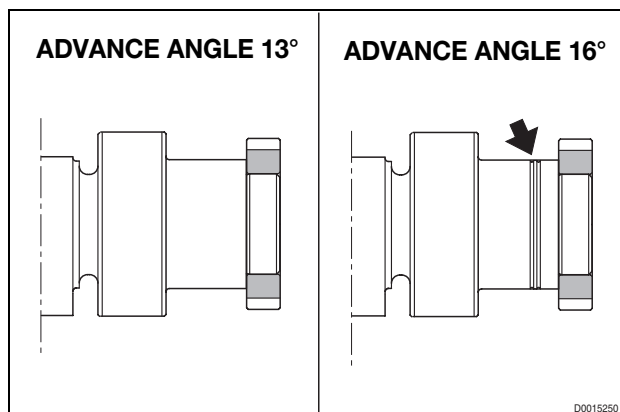
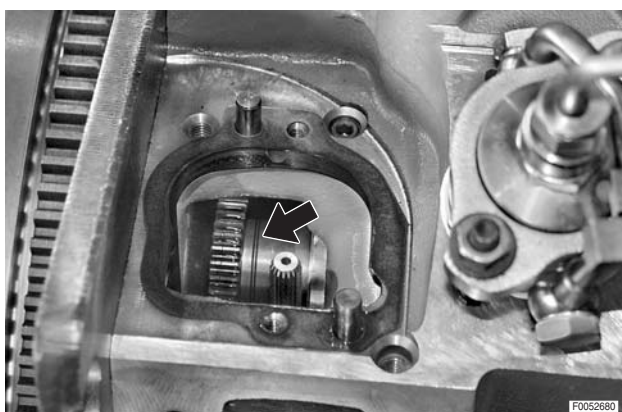
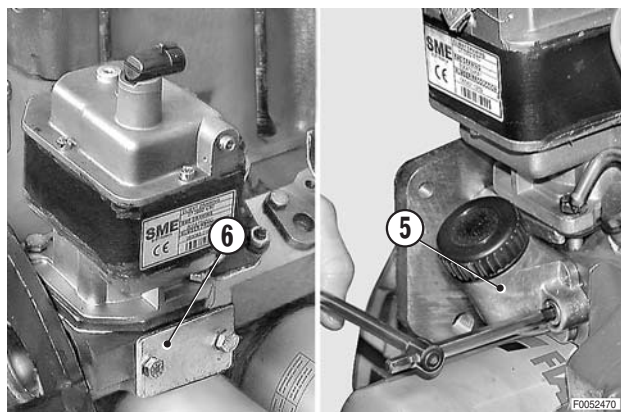
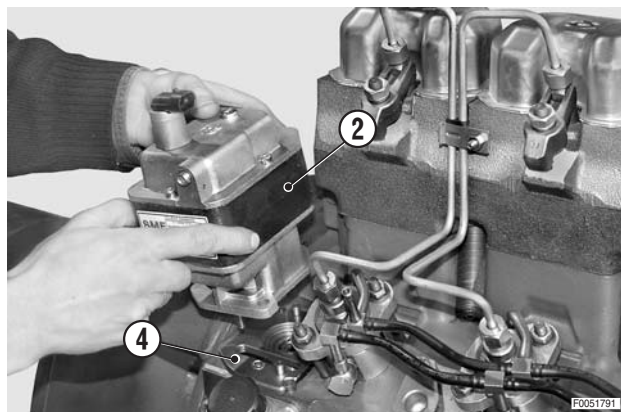
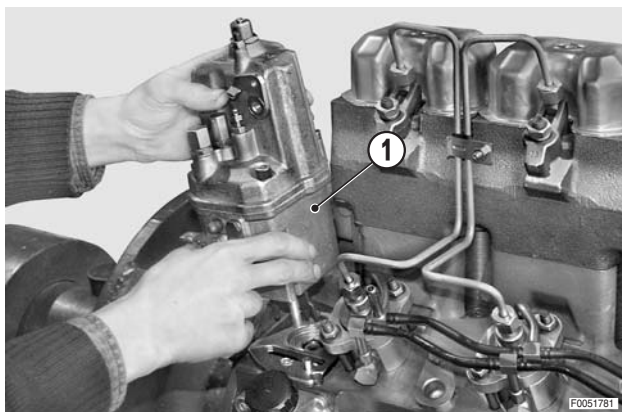
## DETERMINING THE INJECTION ADVANCE ANGLE

★ For details of the various removal and refitting operations, refer to the descriptions in this manual.

The injection advance angle (BTDC) is indicated on the engine data plate; if the plate has been damaged so that it is illegible, the advance angle can be read directly from the camshaft after removing the mechanical governor (1) or the electronic actuator (2) and the governor drive (3) or plate (4) after having removed the filler (5) or the cover (6).

The injection advance angle can be deduced from the presence or absence of lines marked on the camshaft as follows:

- absence of marking: advance angle =  $13^{\circ}$
- presence of markings: advance angle =  $16^{\circ}$





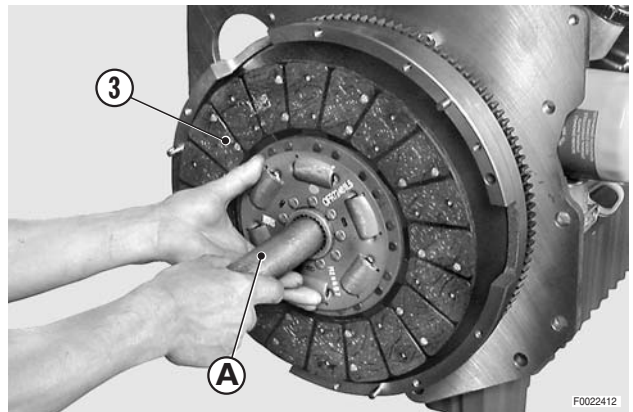
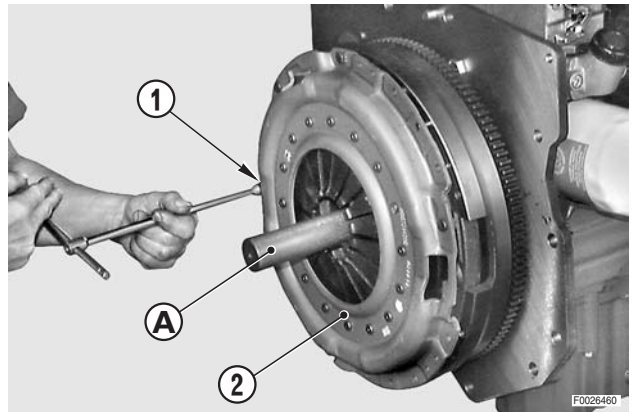
## ENGINE DISASSEMBLY

### 1. PRELIMINARY REMOVAL OPERATIONS

- 1 - Prior to engine disassembly, remove:
  - the starter motor;
  - the radiator cooling fan and its drivebelt;
  - the alternator, the oil filters and, if present, the auxiliary power take-off;
  - where present, the air conditioning compressor and its drivebelt;
  - where present, the compressor for the trailer air braking system;
- 2 - Disconnect the control cables from the accelerator lever and stop lever on the mechanical governor, the fuel supply and return pipes.

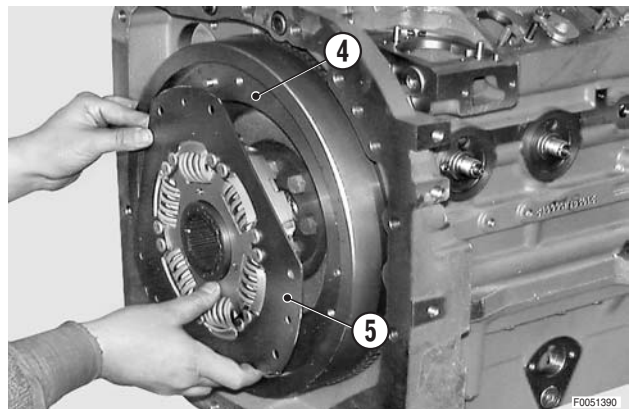
#### Only if the clutch is fitted

- 3 - Screw the guide pin "A" into the centre hole in the crankshaft.
- 4 - Remove the screws (1) and remove the pressure plate (2).  
Loosen the screws gradually and evenly in a cross-wise sequence.
- 5 - Remove the clutch plate (3).
- 6 - Remove the guide pin "A".



#### On some versions only

- 7 - Remove the flexible coupling (5) from the engine fly-wheel (4).
  - ★ Carefully inspect the flexible coupling; if the central hub shows excessive radial play, if the springs are deformed or show radial play, the coupling should be renewed.



**On some versions only**

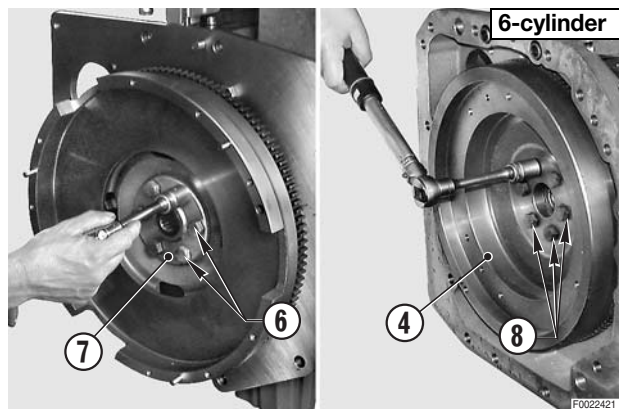
8 - Unscrew the self-locking screws (6) and remove the flywheel retaining flange (7).

★ Fit new screws on reassembly.

**6-cylinder version**

8a - Remove the self-locking screws (8) securing the flywheel (4).

★ Fit new screws on reassembly.



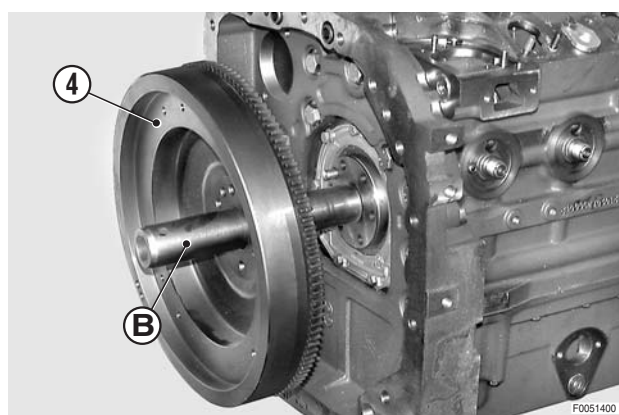
9 - Screw the locating dowel "B" fully into the hole in the centre of the crankshaft.

10 - Remove the flywheel (4).

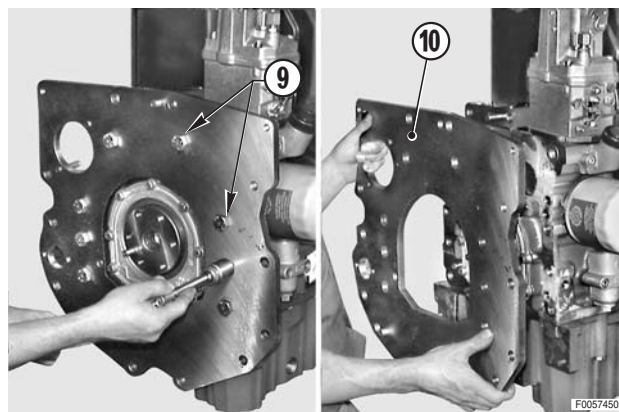
★ To dislodge the flywheel, use a lever on both sides.



Flywheel: from 26 kg to 50 kg  
(from 55 to 110 lb.)

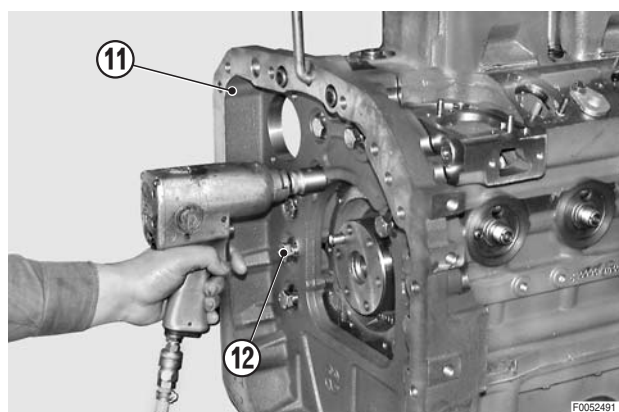


11 - Remove the bolts (9) and remove the flange (10).

**On some 6-cylinder versions**

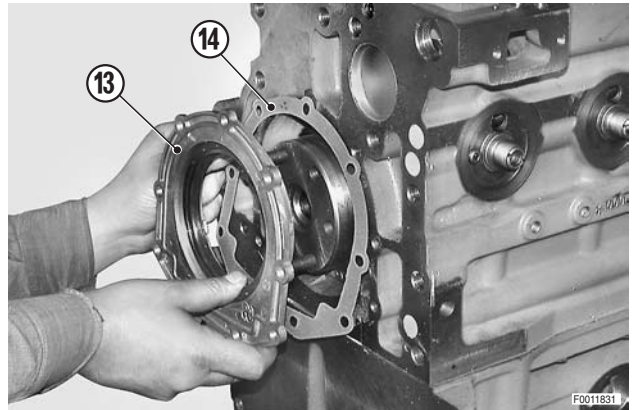
11a - Attach the flywheel housing flange (11) to a hoist and put the lifting cable under slight tension.

11b - Remove the bolts (12) and remove the flywheel housing flange (11).

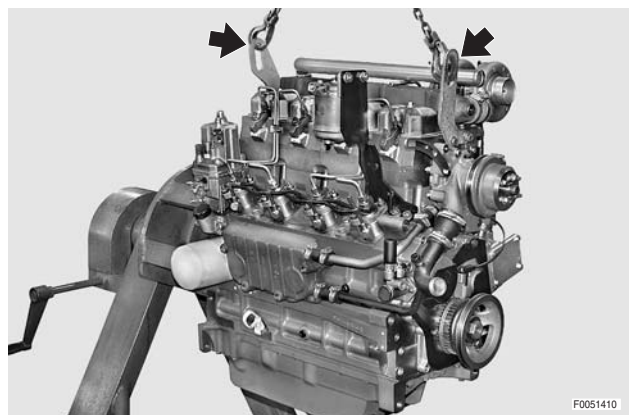




- 12 - Remove the screws and remove the rear oil seal cover (13) complete with its gasket (14).  
★ Fit a new oil seal on reassembly.



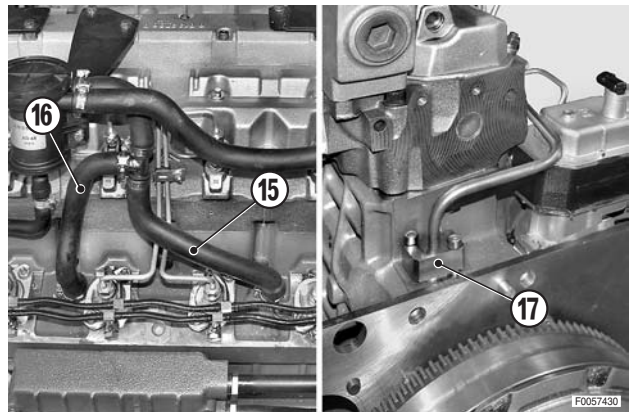
- 13 - Attach the lifting brackets of the engine to a hoist and mount the engine on a suitable engine stand capable of supporting and rotating the engine.



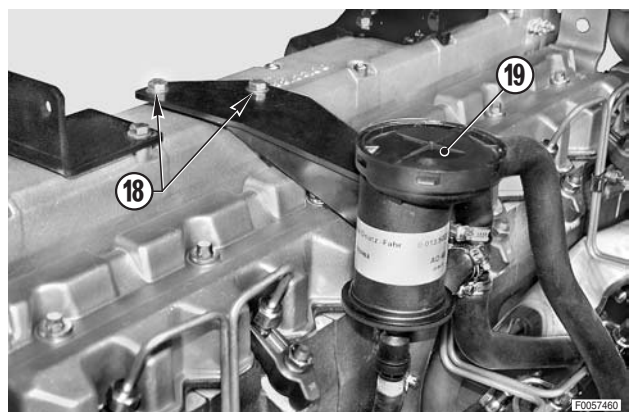
### Removal of the blow-by assembly

**!** The blow-by assembly illustrated is just one of the solutions adopted; assemblies fitted to other engine models may differ from that shown, but the removal procedure is the same.

- 14 - Loosen the clamps and disconnect the oil vapour recovery pipes (15) and (16).  
15 - Unscrew and remove the screws and remove the oil recovery flange (17).  
★ Renew the oil seal on reassembly.



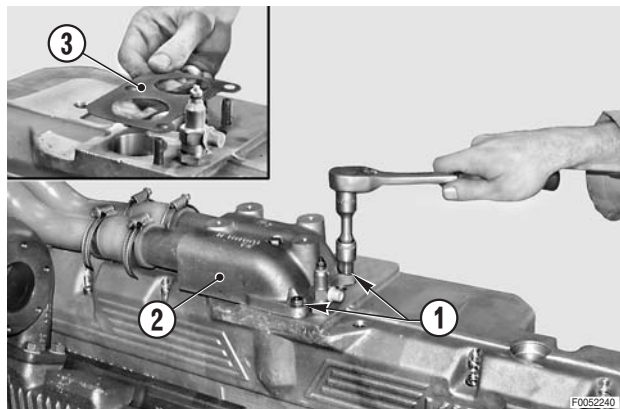
- 16 - Remove the screws (18) and remove the blow-by assembly (19) complete with pipes.



## 2. REMOVAL OF THE COOLING AND INTAKE PIPES

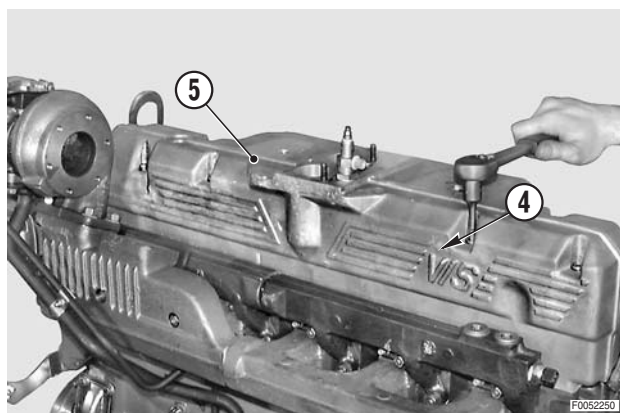
### 1000.6WT-WTI/V.I.S engines.

- 1 - Remove the nuts (1) with their washers and remove the air intakes (2).
- 2 - Remove the gasket (3).
- ★ Fit a new gasket on reassembly.



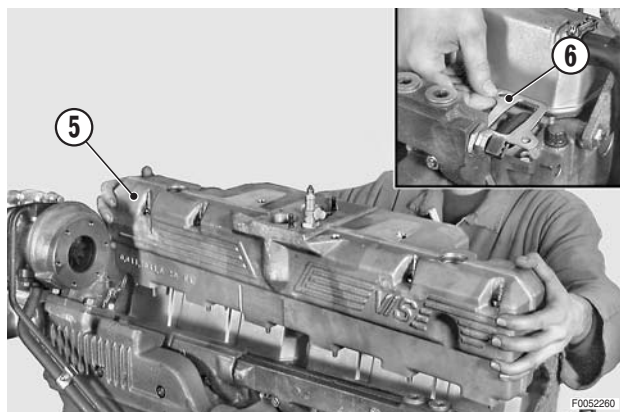
### Solo per V.I.S.

- 3 - Loosen and remove the retaining bolts (4) of the inlet manifold (5).



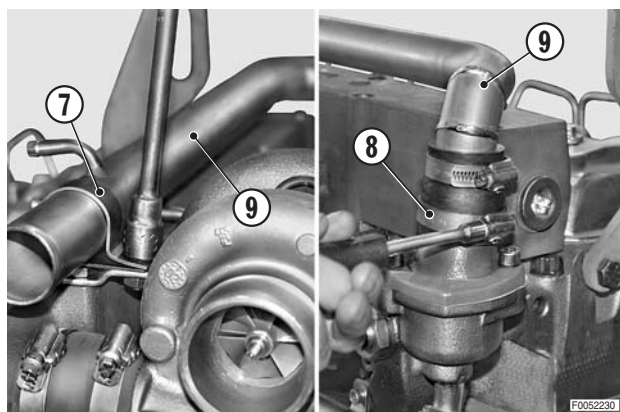
### For versions with V.I.S. only

- 4 - Remove the inlet manifold (5) and the gaskets (6).
- ★ Fit a new gasket on reassembly.

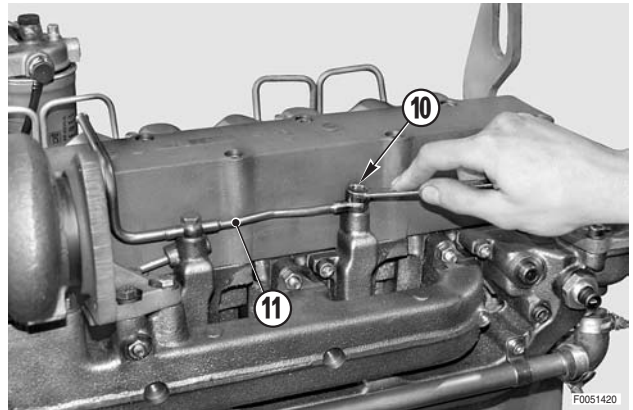


### 1000W - WT - WTI a 3-4 cylinder engines

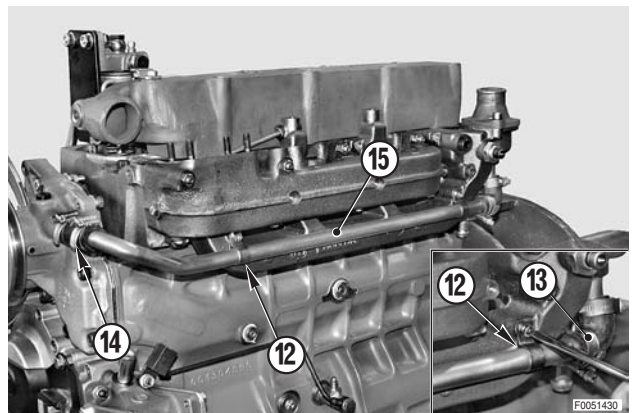
- 5 - Slacken off the hose clamps (7) and (8); remove the radiator connection hose (9).



- 6 - Loosen and remove the fittings (10) and remove the pipe (11).

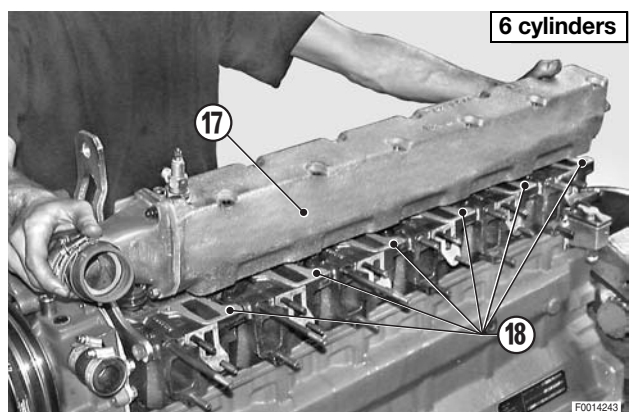
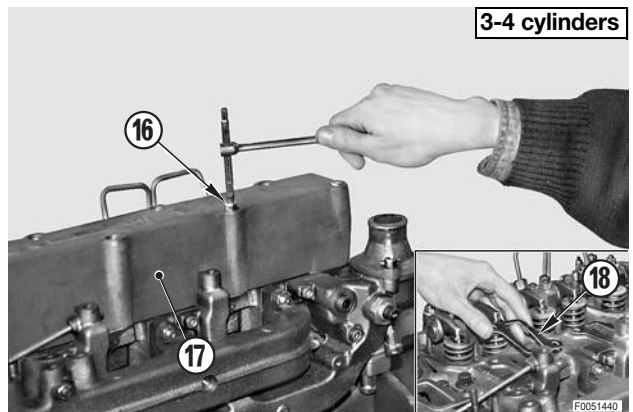


- 7 - Loosen the hose clamps (12), (13), (14) and remove the hose (15).



### W 3-4-6 cylinder engines (naturally aspirated version)

- 8 - Unscrew and remove the screws (16) and remove the inlet manifold (17) with its gaskets (18).  
★ Renew the gaskets on reassembly.

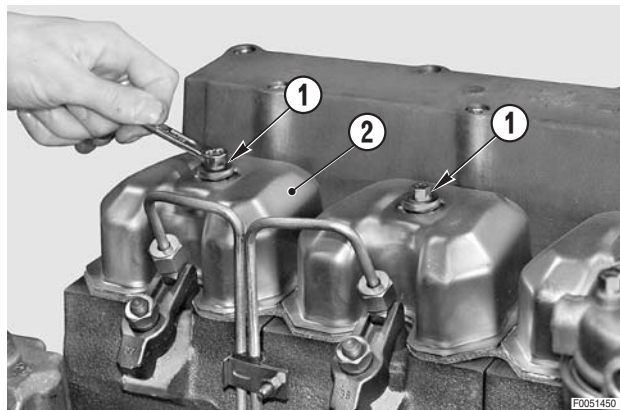




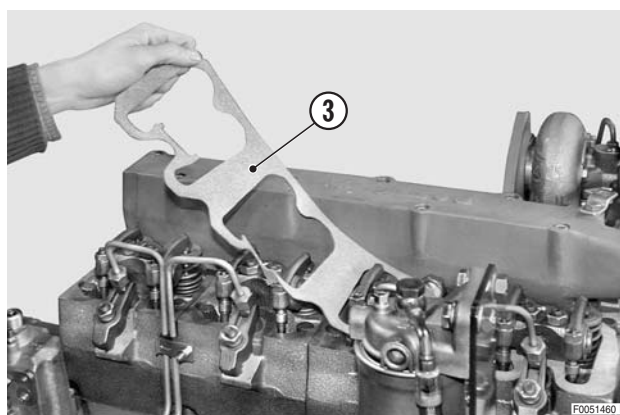
### 3. REMOVAL OF THE CYLINDER HEADS

#### 3/4-cylinder version

- 1 - Remove the screws (1) and remove the rocker covers (2).
  - ★ Carefully check the O-rings.

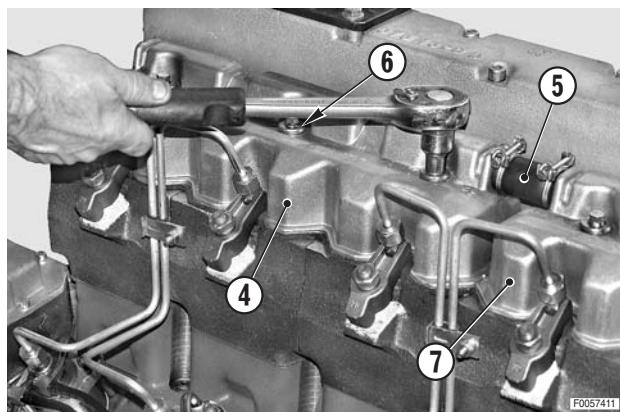


- 2 - Remove the gasket (3) and discard it.

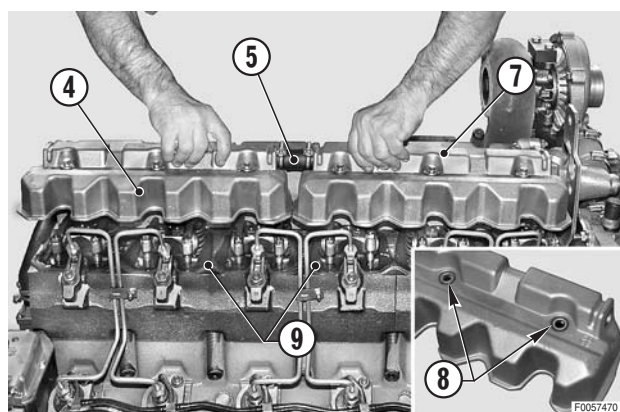


#### 6-cylinder version

- 3 - Remove the screws (6) securing rocker covers (4) and (7).
  - ★ Do not remove the connection hose (5).

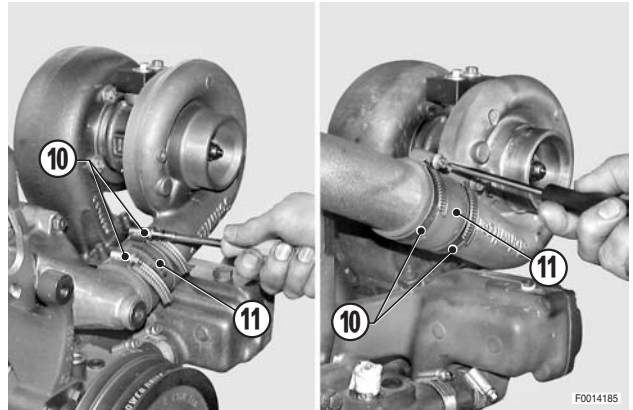


- 4- Lift the two rocker covers (4) and (7) simultaneously and remove them from the cylinder head.
  - ★ Carefully check the condition of O-rings (8).
  - ★ Discard the old rocker cover gaskets (9).



**WT - WTI Versions**

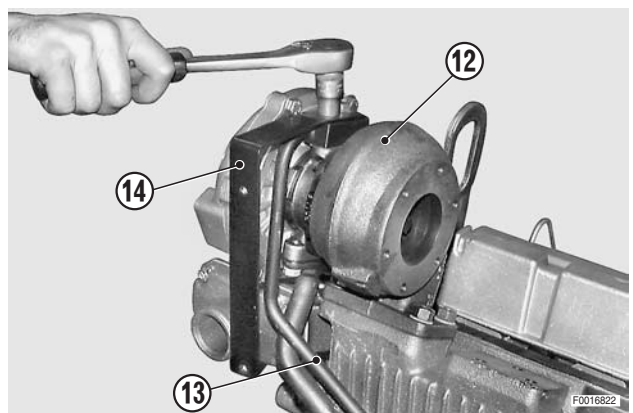
5 - Loosen the clamp (10) securing the inlet hose (11).



6 - Disconnect the lube oil delivery pipe (13) from the turbocharger (12).

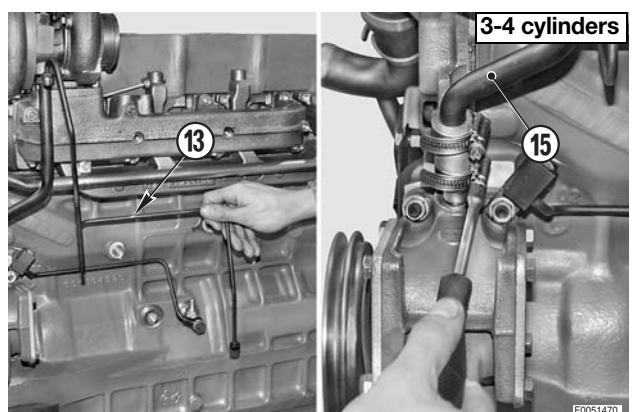
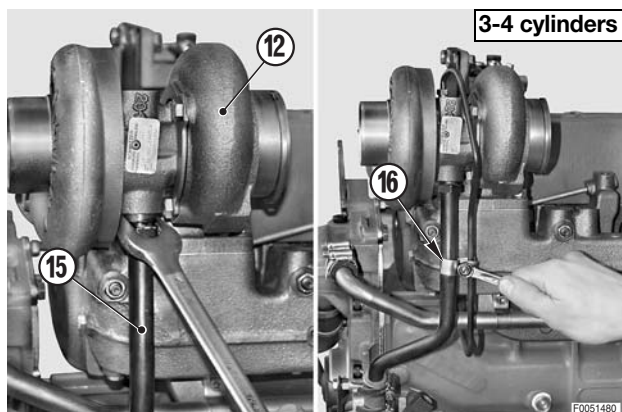
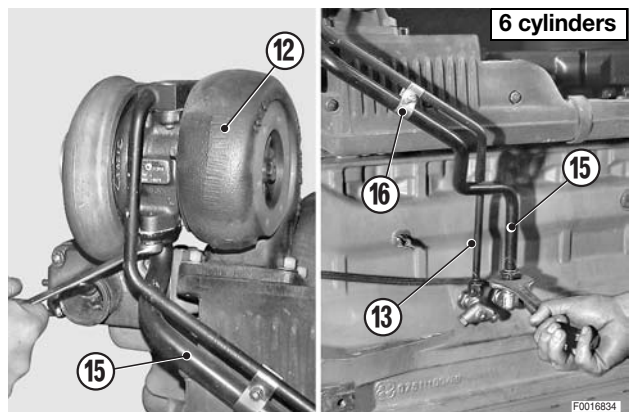
**For some 6-cylinder versions only.**

Remove also the bracket (14) that supports the left-hand guard.



7 - Disconnect the lube oil delivery and return (15) pipes from the turbocharger (12); loosen clamp (16), disconnect the pipes (13) y (15) from their fittings on the crankcase and remove them.

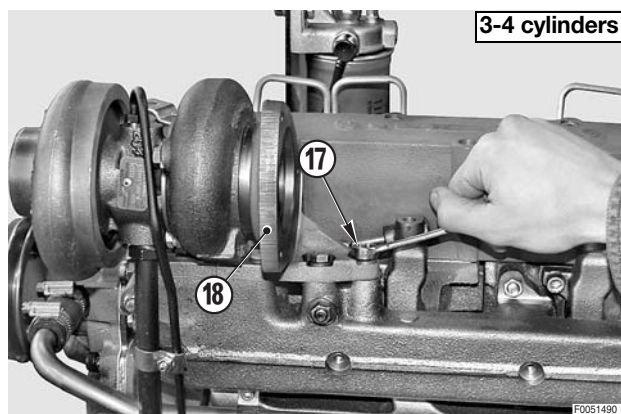
★ Always renew the seals on the turbocharger fittings.



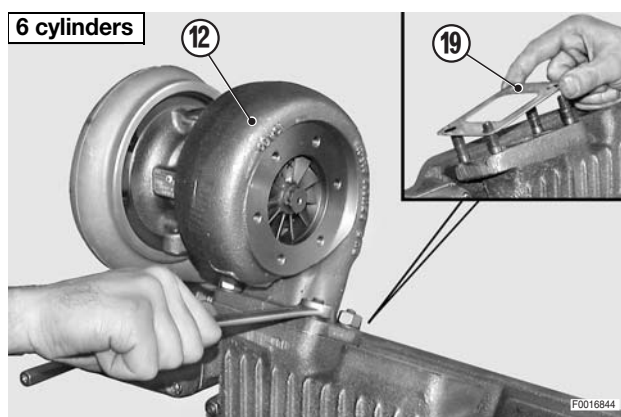
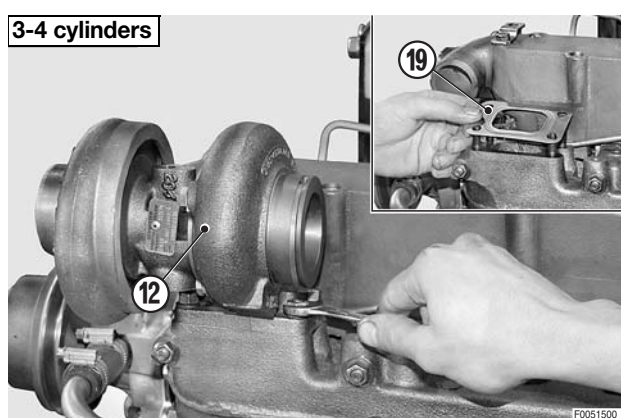
**3/4-cylinder versions**

- 8 - Unscrew and remove the bolts (17); remove the silencer flange (18) in the direction of its axis.

★ Take care not damage the seal.

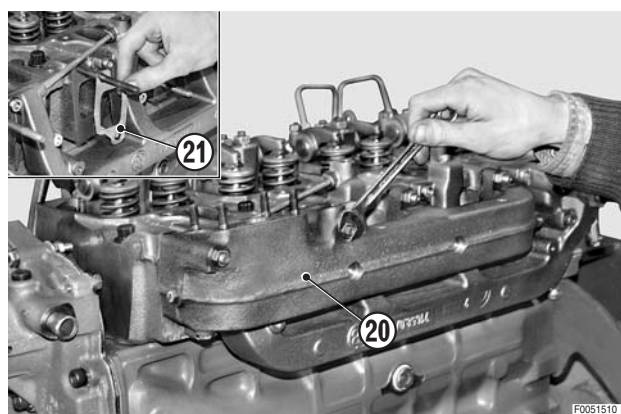


- 9 - Remove the retaining nuts and washers and remove the turbocharger (12) along with its gasket (19).

**3- and 4-cylinder versions**

- 10 - Remove the nuts and remove the exhaust manifold (20) with the gaskets (21).

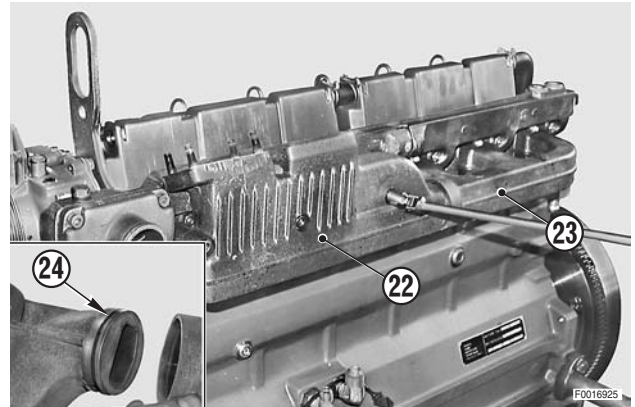
★ Fit new gaskets on reassembly.



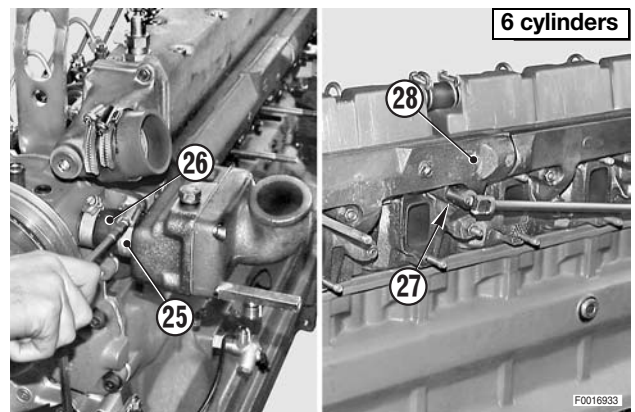
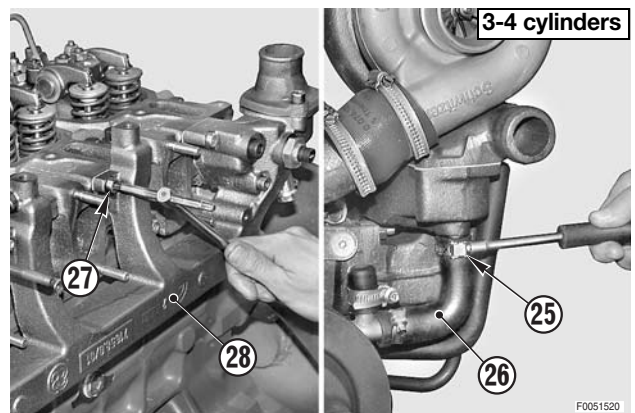


**6-cylinder versions**

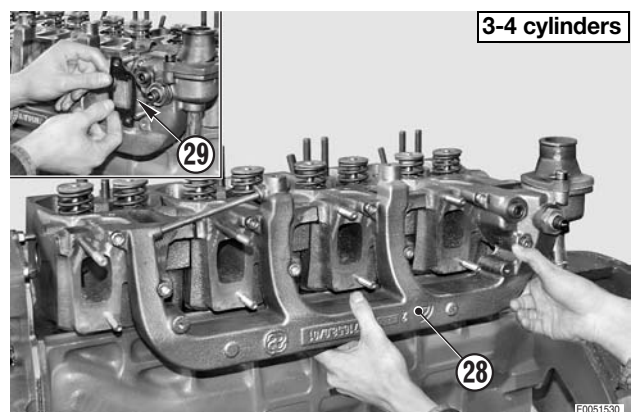
- 11 - Remove the retaining nuts and spring washers and then remove both exhaust manifolds (22) and (23) simultaneously.
- ★ Check the condition of the seal (24) at the joint between the two manifolds.
  - ★ Fit new gaskets on reassembly.

**For certain versions only**

- 12 - Loosen the clamp (25) securing the hose (26) of the coolant pump.
- 13 - Remove the bolts (27) and washers securing the manifold (28).

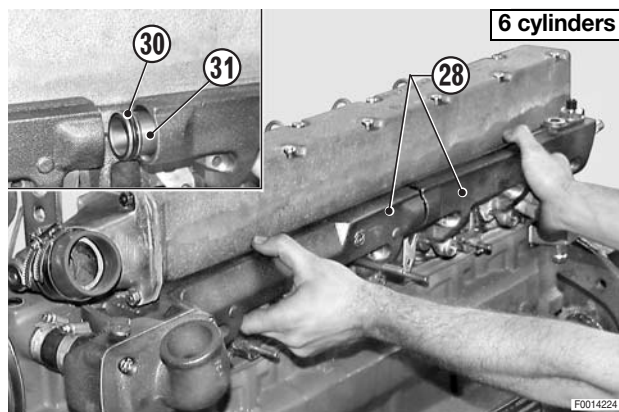


- 14 - Removing collecting pipes (28) complete with the thermostatic valves.
- ★ Renew the gasket (29) on reassembly.
  - ★ On 3-4 cylinder versions, the manifold is a one-piece part with only one valve.

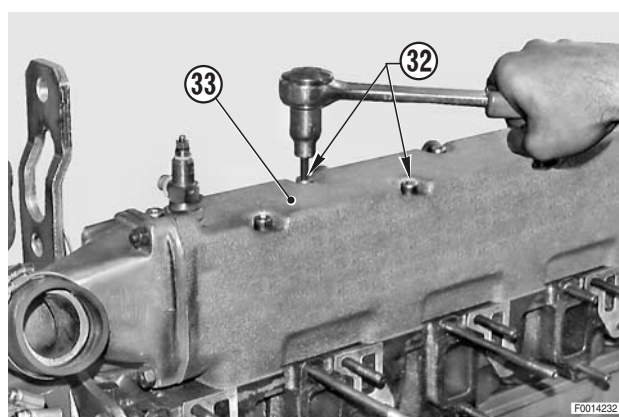


**For 6-cylinder versions**

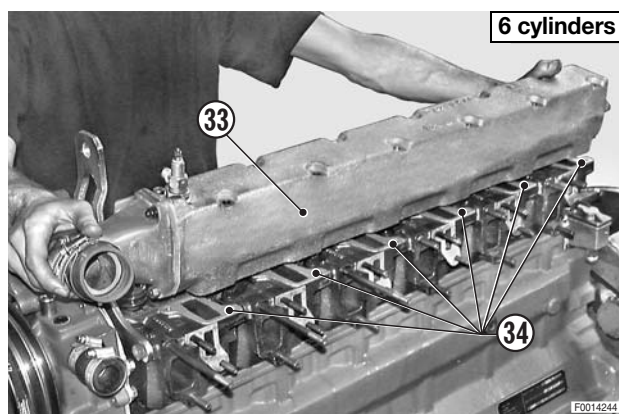
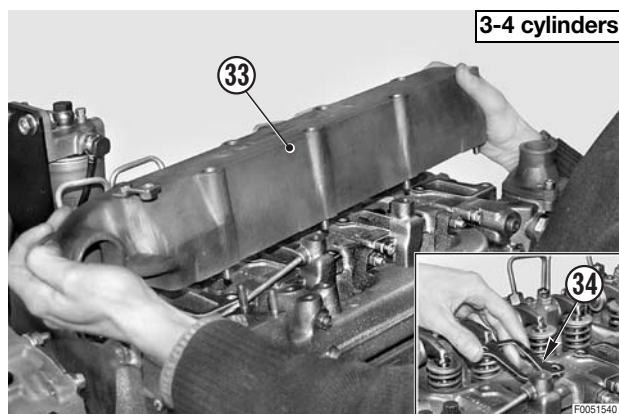
- ★ Always renew the O-rings (30) at the connecting hose (31).
- ★ To check the thermostatic valves, see «Sect. 30 - REMOVAL AND INSPECTION OF THE THERMOSTATIC VALVES».



- 15 - Loosen and remove the retaining bolts (32) of the inlet manifold (33).

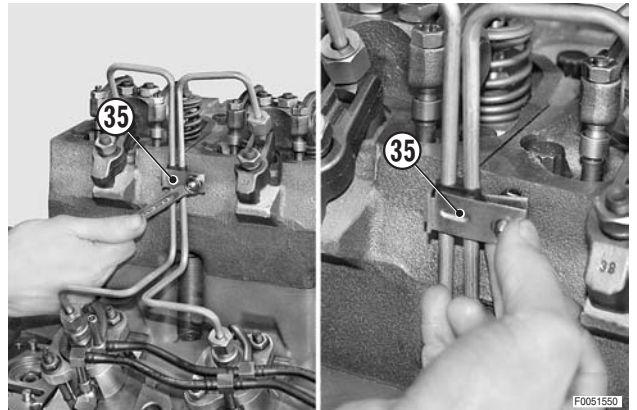


- 16 - Remove the inlet manifold (33) with the gaskets (34).  
 ★ Fit new gaskets on reassembly.



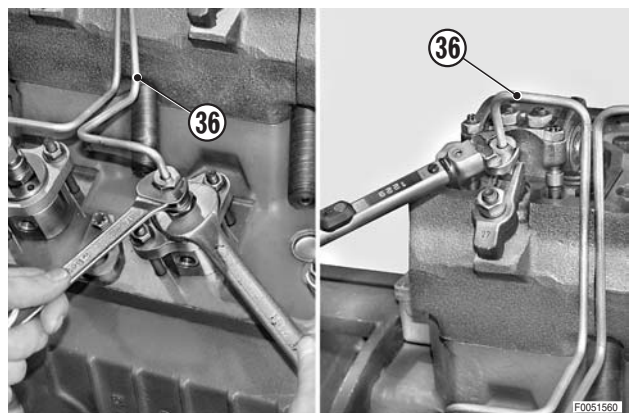


17 - Remove the vibration damper clamps (35).



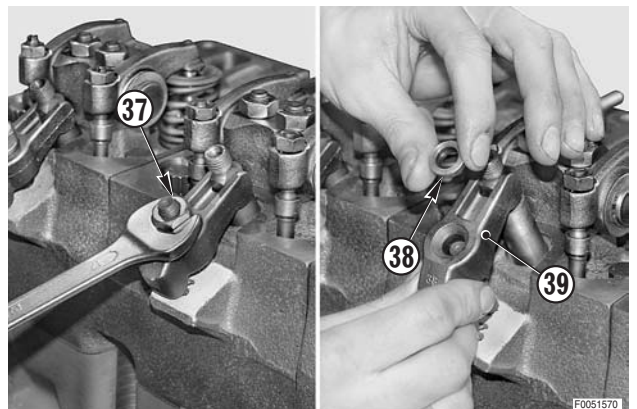
18 - Remove the high-pressure fuel pipes (36).

- ★ Hold the pump union firm while loosening the union on the pipe.



19 - Remove the nuts (37) and tapered washers (38).

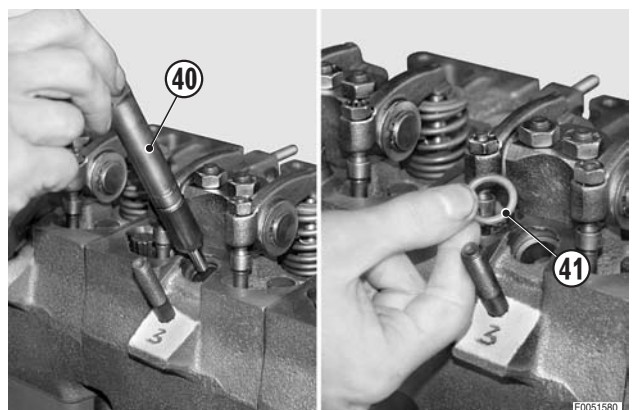
20 - Remove the injector mounting bracket (39).



21 - Extract the injectors (40) and the O-rings (41).

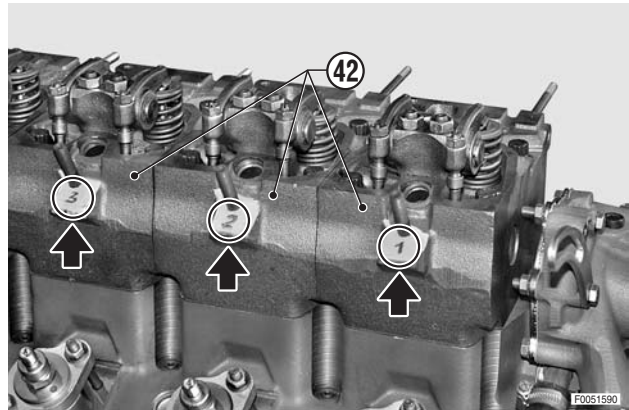
- ★ Renew the O-rings on reassembly.
- ★ Note which way the round the injectors are installed.

⚠ Protect the delivery hole and the injector nozzle with caps to prevent impurities getting in.

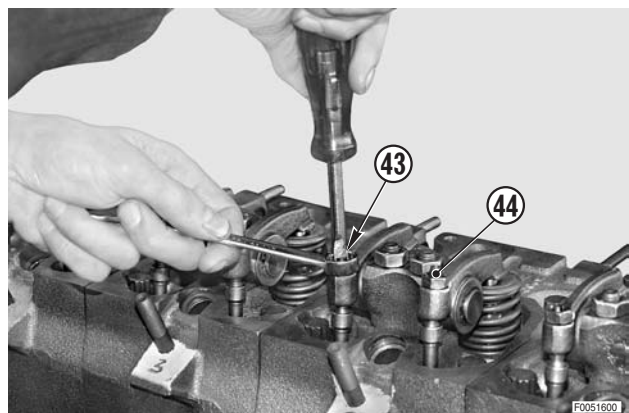


22 - Mark the cylinder heads (42) according to their respective positions on the engine block.

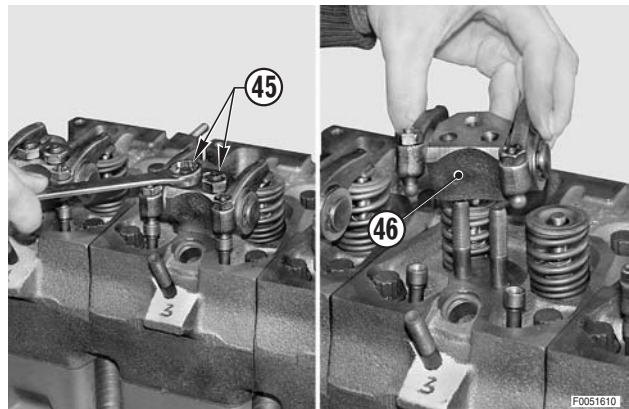
- ★ Start numbering the heads from cylinder N.1 (at opposite end to the flywheel).



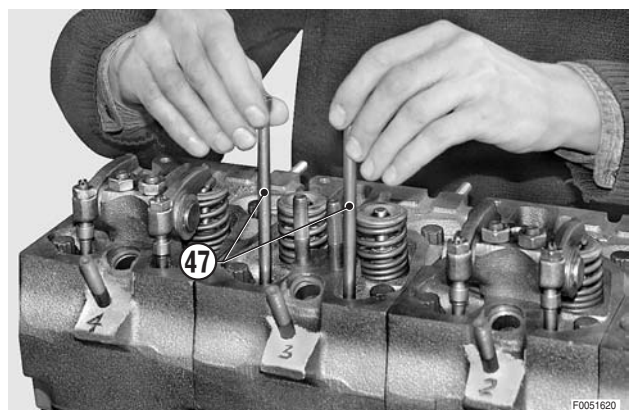
23 - Loosen the nuts (43) of the tappets (44) and unscrew the tappets sufficiently to release the rocker arms.



24 - Remove nuts (45) and remove the complete rocker arm support assemblies (47).

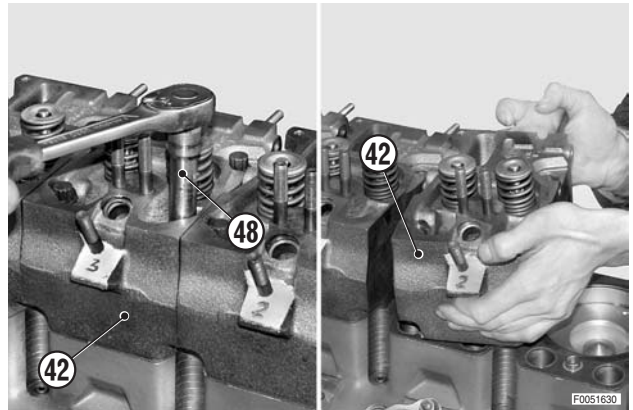


25 - Withdraw the (47) pushrods.



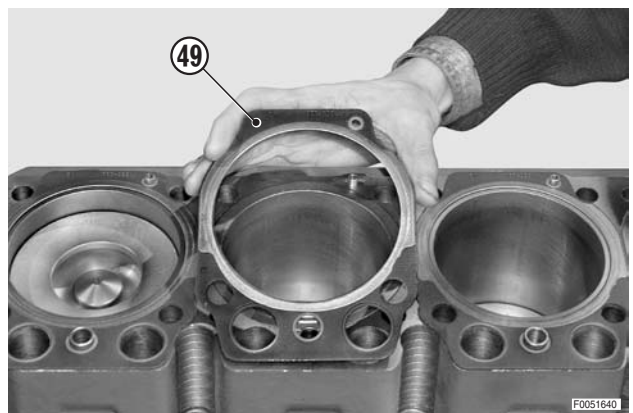
26 - Loosen and remove the retaining bolts (48) of the cylinder heads (42).

27 - Remove the complete cylinder head assemblies (42).



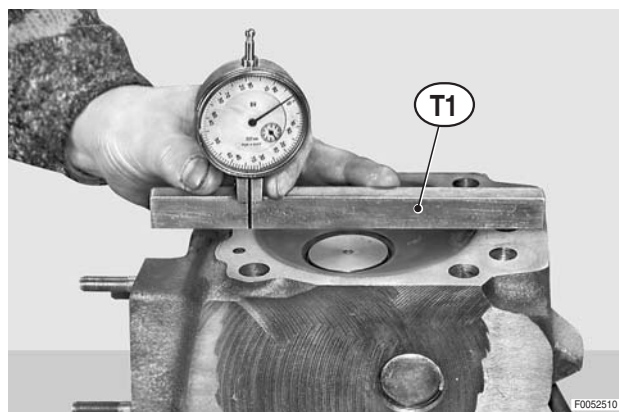
28 - Remove the head gaskets (49).

- ★ If the cylinder heads are to be refitted without renewing the cylinder liners, make a note of the type of gasket used for each cylinder head. The thicknesses of the head gaskets can be determined by the presence or absence of identification holes punched in the tab with central oil hole. (For details, see «22 DETERMINING GASKET THICKNESS AND CYLINDER HEAD ASSEMBLY»).



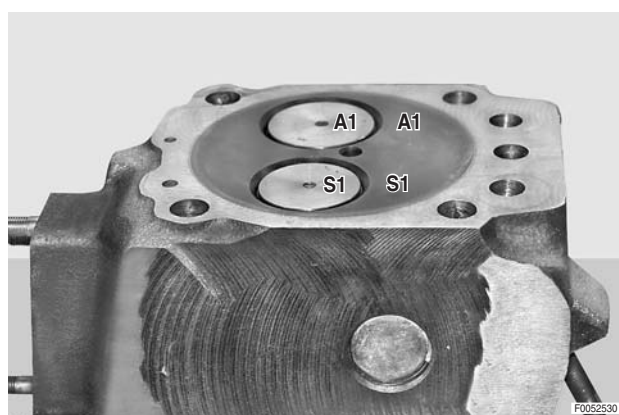
### 3.1 Dismantling the cylinder heads

- 1 - Before dismantling, carefully clean the surfaces of the cylinder heads and the valves.  
Using tool **T1** (code 5.9030.433.0) and a dial gauge, check that the stand-in of the inlet and exhaust valves is within the permissible limits. (See «TESTS AND TECHNICAL DATA»).

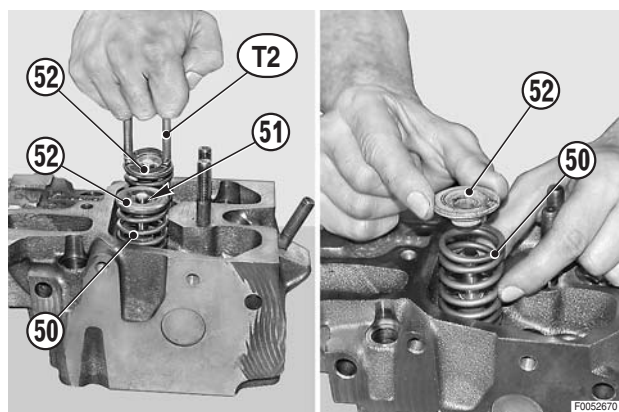


- 2 - If the valve stand-in is within the prescribed limits, before removing the valves, mark their positions relative to the cylinder head so that, if not damaged, they may be refitted in their original positions.

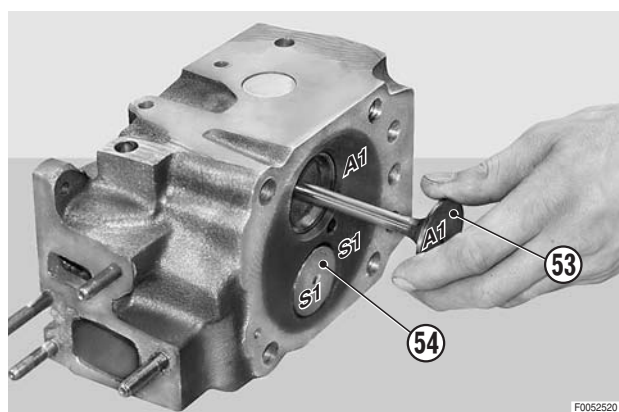
Example: Cylinder head 1 - A1 - S1  
2 - A2 - S2



- 3 - Using tool **T2** (code 5.9030.012.0), compress the springs (50) and remove the split collets (51) of valves.
- 4 - Release the pressure and remove the springs (50) and spring plates (52).



- 5 - Withdraw valves (53) and (54).



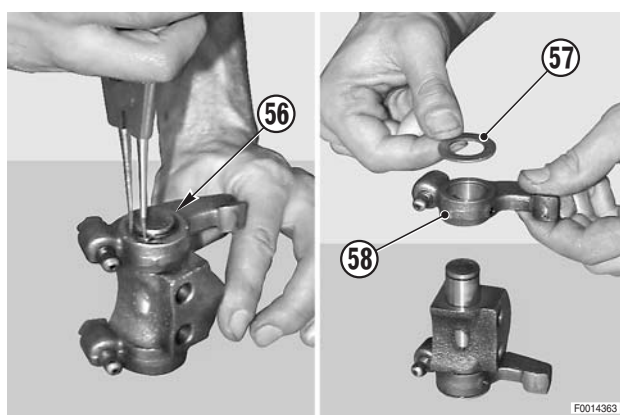


- 6 - Using a screwdriver or lever, remove the valve seals (55).



### 3.2 Dismantling the rocker arm supports

- 1 - Remove circlips (56).
- 2 - Remove thrust washers (57) and remove rocker arms (58).

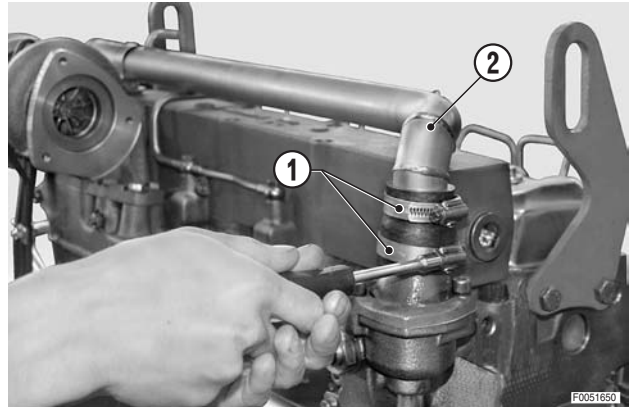


## 4. REMOVAL AND TESTING OF THE THERMOSTATS

### 4.1 REMOVAL

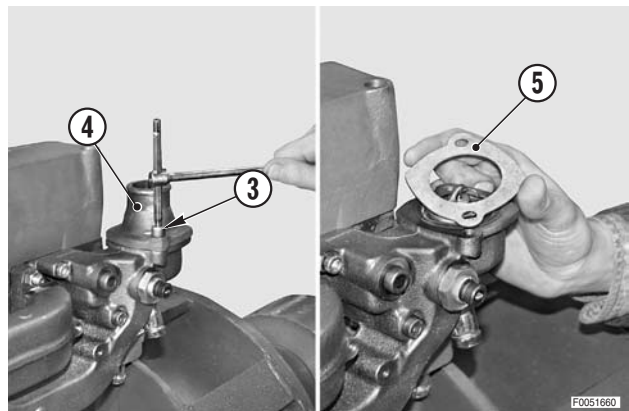
#### 4.1.1 3- and 4-cylinder versions

- 1 - Remove the clamps (1) and disconnect the pipe (2) from the thermostat.

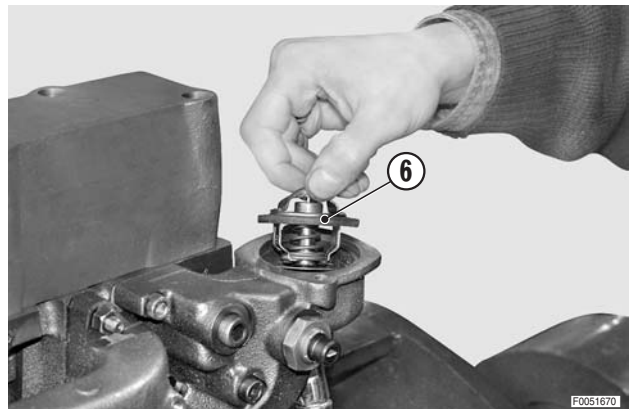


- 2 - Loosen and remove the screws (3) and remove the cover (4) and the gasket (5).

★ Fit a new gasket on reassembly.

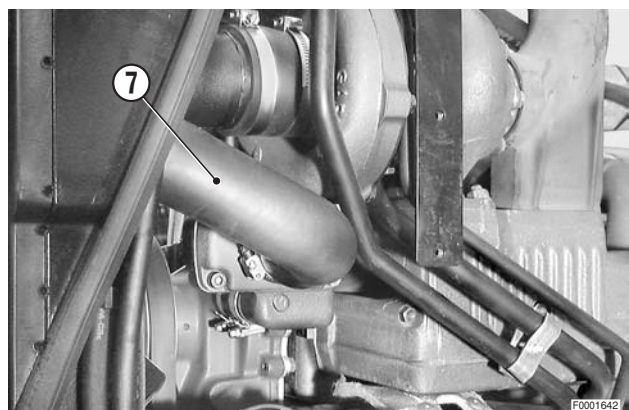


- 3 - Remove the thermostat (6).



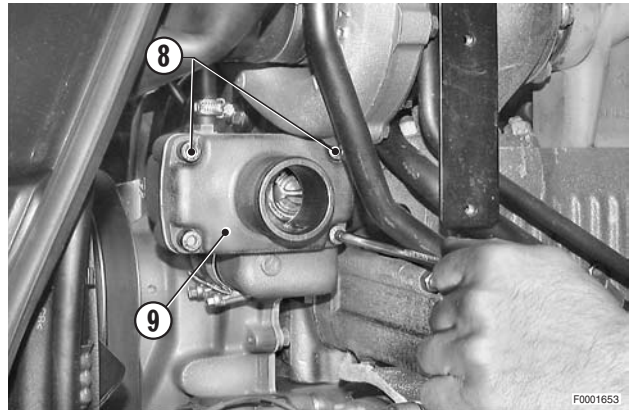
#### 4.1.2 6-cylinder versions

- 1 - Disconnect the radiator connection pipe (7) from the thermostat cover.

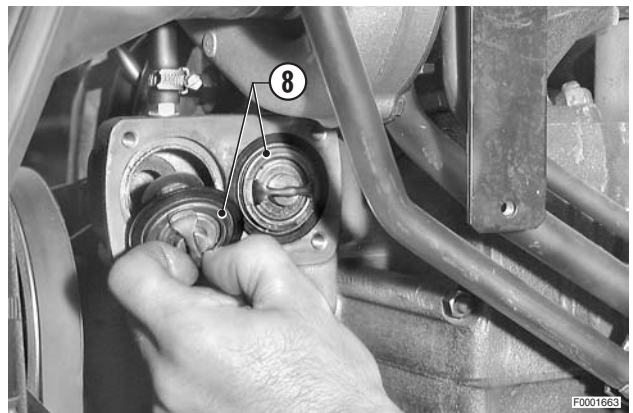


- 2 - Loosen and remove the screws (8) and, using a soft-faced mallet, remove the cover (9).

※ 1



- 3 - Remove the thermostats (6) for testing or renewal.

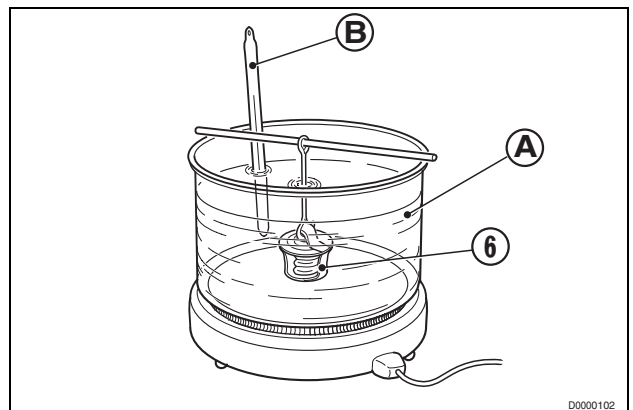


#### 4.2 TESTING THE THERMOSTATS

- 1 - Fully immerse the thermostat in a bowl "A" containing liquid coolant.
- 2 - Heat the coolant, checking the temperature with a thermometer "B".
- 3 - Check that the thermostat valve aperture is 0.1 mm (0.004 in.) when the temperature of the coolant is  $79 \pm 2$  °C (174.2  $\pm$  35.6 °F) and that the aperture is 7 mm (0.276 in.) when the temperature reaches 94 °C (201.2 °F).



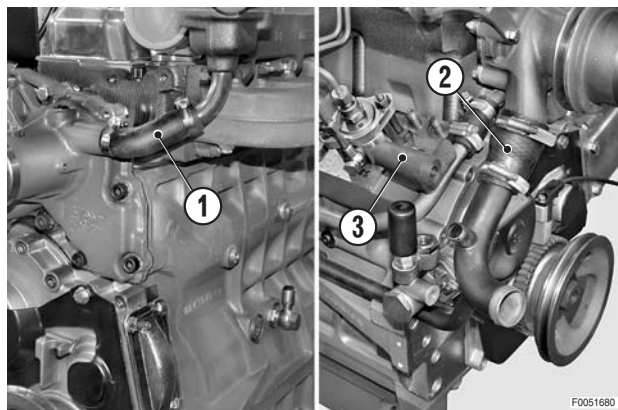
If the thermostat (6) does not behave as described above, it should be renewed.  
Do not attempt to adjust the thermostat settings.



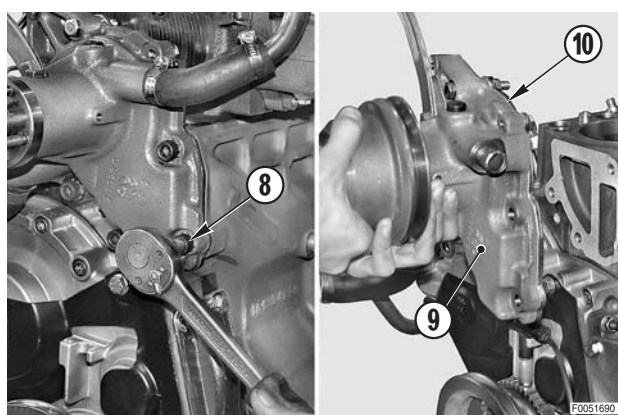
## 5. REMOVAL OF THE COOLANT PUMP

### 5.1 3- AND 4-CYLINDER VERSIONS

- 1 - Loosen the clamps and disconnect hoses (1) and (2) from the pump.
- 2 - Remove the alternator support (3).

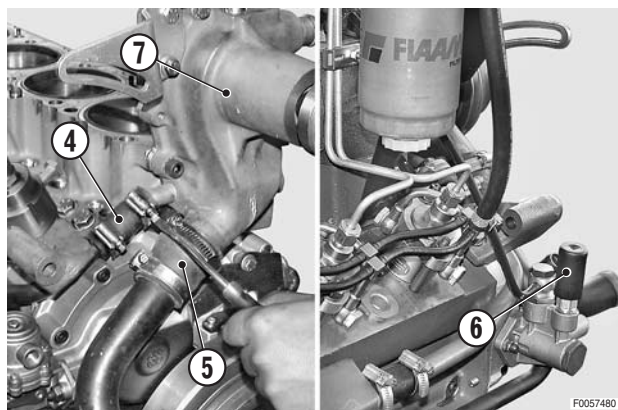


- 3 - Unscrew and remove the bolts (8); remove the pump (9) and its gasket (10).
- ★ Renew the gasket on reassembly.



### 5.2 6-CYLINDER VERSIONS

- 1 - 1a - Loosen the hose clamps and move the hoses (4), (5) and (6). Remove the pump (7) and its gasket.
- ★ Fit a new gasket on reassembly.

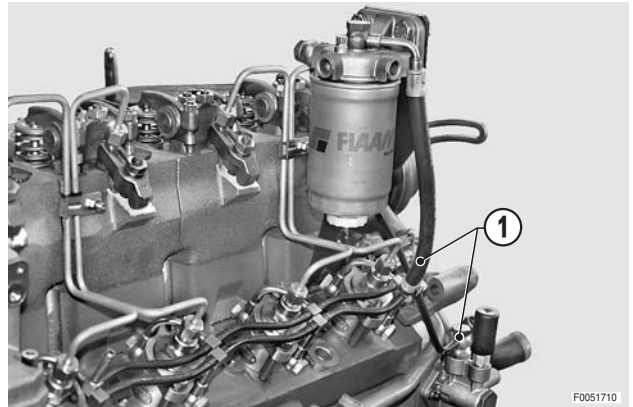




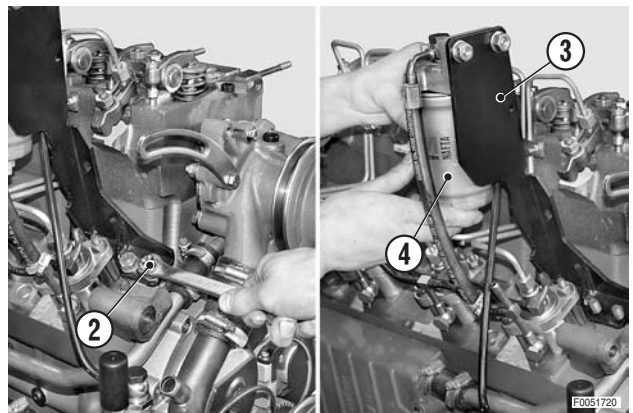
## 6. REMOVAL OF THE UNIT PUMPS, ACTUATOR AND FUEL LIFT PUMP

### For certain versions only

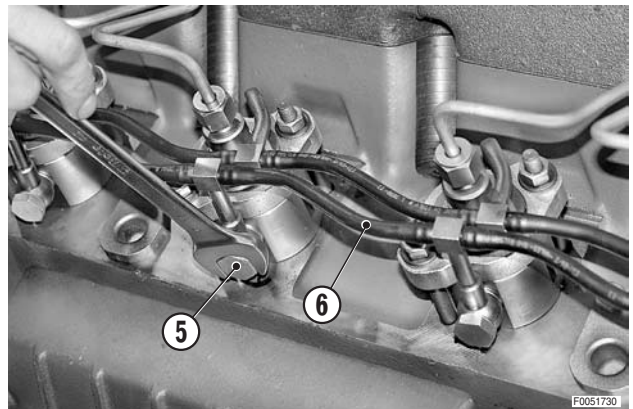
- 1 - Disconnect the pipes (1) connecting the fuel filter to the fuel lift pump and to the fuel distribution circuit.
- ★ Plug the pipes to prevent impurities getting in.



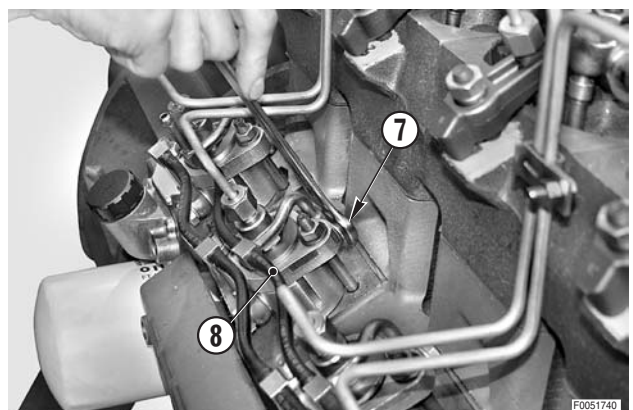
- 2 - Unscrew and remove the nuts (2) and washers securing the filter support bracket (3).
- 3 - Remove the complete filter assembly (4).



- 4 - Undo the unions (5) and remove the fuel supply pipes (6) to the injection pumps.
- ★ Renew the bronze seals of the unions on reassembly.
- ★ Carefully check the threads on the unions; if damaged, renew the union using original parts only (code 2.3249.093.2).
- ⚠ Immediately plug the open holes of the pump with the unions (5) to prevent impurities getting in.



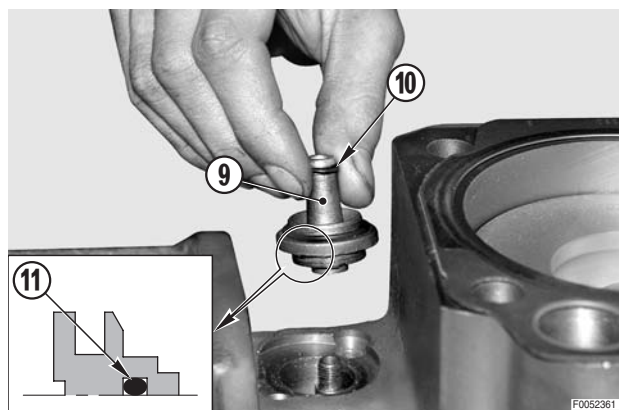
- 5 - Undo the unions (7) and remove the fuel return pipes (8).
- ★ Renew the bronze seals of the unions on reassembly. Use original parts only (code 2.1569.213.0).
- ⚠ Immediately plug the open holes of the pump with the unions (7) to prevent impurities getting in.



**3- and 4-cylinder versions**

6 - Remove the drain fitting (9) from the oil mist separator.

- ★ Inspect the O-rings (10) and (11) carefully and renew them if in any doubt about their condition.

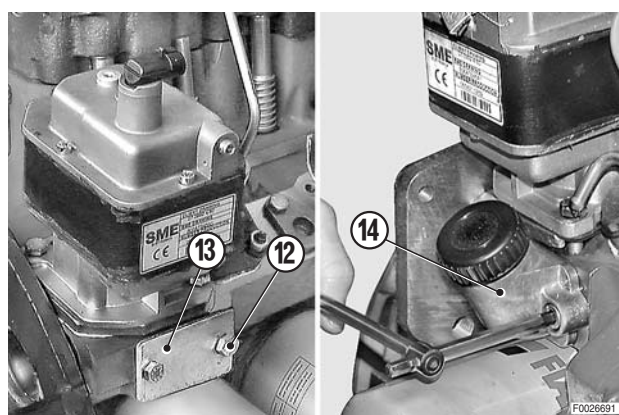


7 - Remove the bolts (12) and remove the inspection cover (13) complete with its gasket.

**3- and 4-cylinder versions**

Remove the oil filler (14).

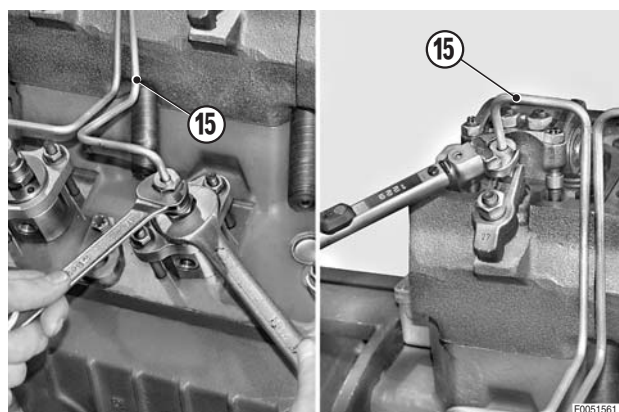
- ★ Inspect the O-rings and carefully and renew them if in any doubt about their condition.



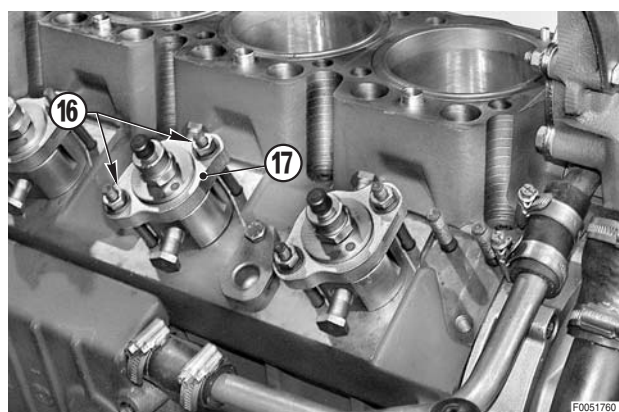
8 - Remove the high-pressure pipes (15) that supply fuel to the injectors.

(For details, see «REMOVAL OF THE CYLINDER HEADS»).

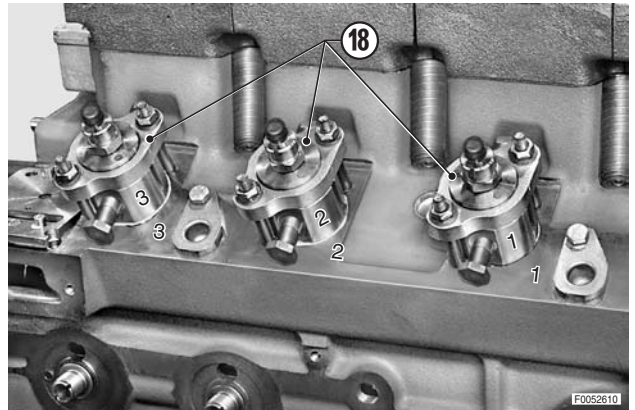
- ⚠ After removing the high-pressure pipes, immediately plug the open fittings on the pump.



9 - Progressively loosen and remove the lock nuts (16) and the flanges (17) of the injectors.

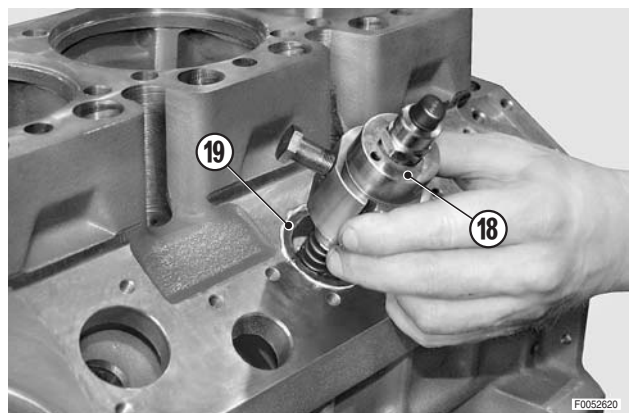


- 10 - Record the positions of the injection pumps (18) and the relative shims (19) to avoid confusion during re-assembly.



- 11 - Manually move the control rod to the mid-stroke position, remove the retaining nuts and washers and then remove the injection pump (18) along with the shim pack (19).

★ Note that if the shims and the pumps are mixed up and not refitted in their original positions, then it will be necessary to carry out the timing procedure on all the pumps.



- 12 - Extract the rollers (20).

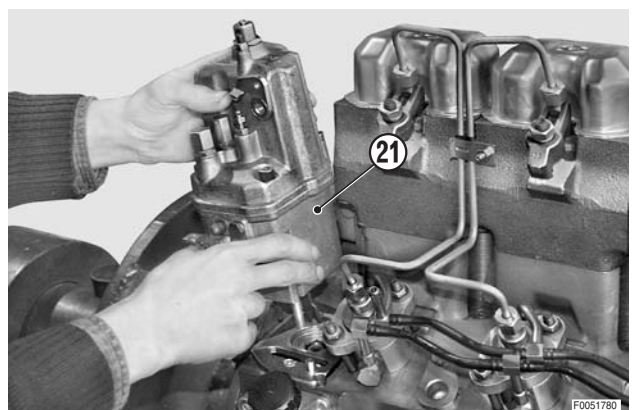


### Version with mechanical governor

- 13 - Remove the screws and remove the mechanical governor (121) with its gasket.

★ Fit a new gasket on reassembly.

⚠ If the governor requires overhaul or calibration, see «8. OVERHAUL OF THE MECHANICAL GOVERNOR».



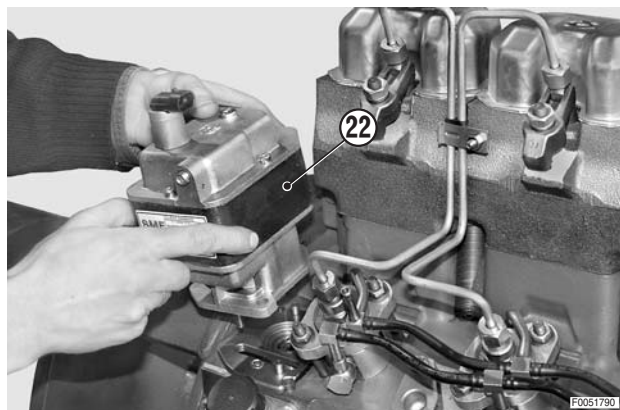


**Version with electronic actuator**

9a - Remove the screws (No. 2) and remove the governor support (22) and gasket.

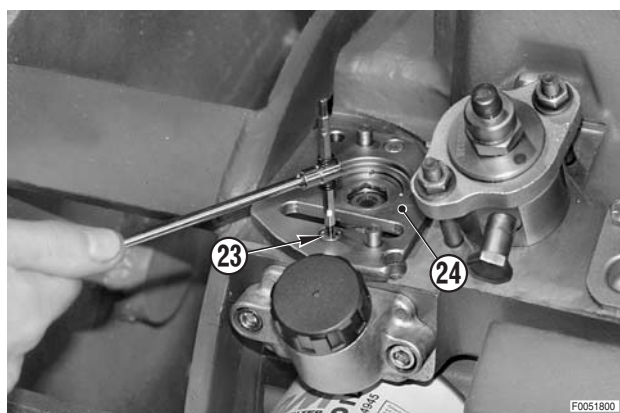
★ Renew the O-ring at each re-assembly.

⚠ For adjustment of the actuator, see «9. ADJUSTMENT OF THE ELECTRONIC ACTUATOR».

**3-, 4- and 6-cylinder versions with mechanical governor****3- and 4-cylinder versions with electronic actuator**

10 - Remove the screws (23) securing the governor drive (24).

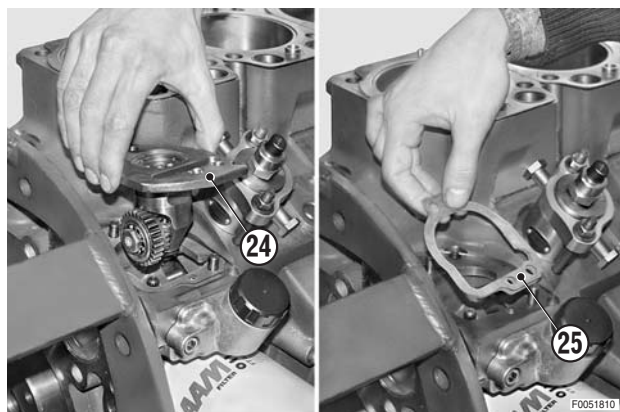
★ On 3- and 4- cylinder versions, this also drives the oil pump.



15 - Remove the governor drive (24) and the gasket (25).

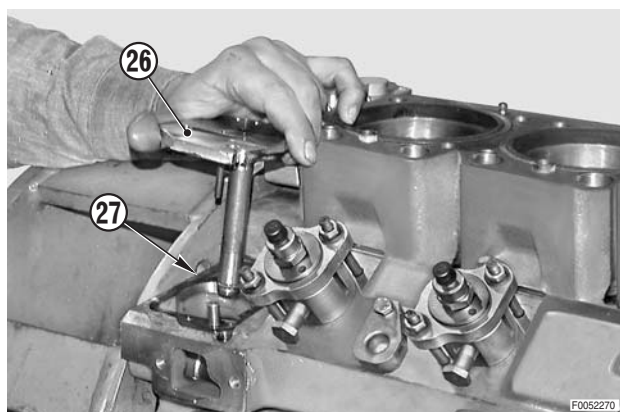
★ Fit a new gasket on reassembly.

★ Note that the gasket is coated with Silastic 738 sealant on both faces.

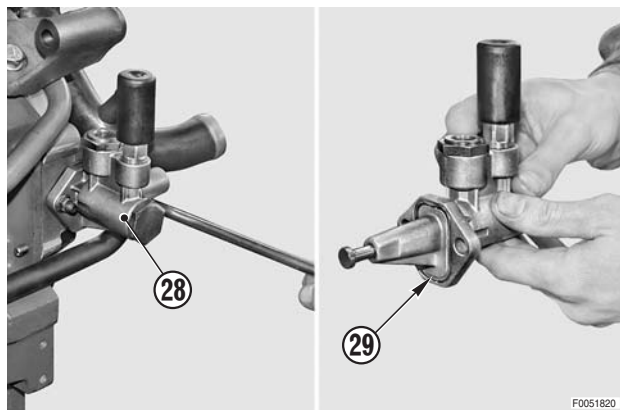
**6-cylinder version with electronic actuator**

11a - Remove the screws and remove the governor support (26) and gasket (27).

★ Renew the O-ring at each re-assembly.



- 16 - Undo the nuts and remove the fuel lift pump (28).  
★ Carefully inspect the condition of the gasket (29).

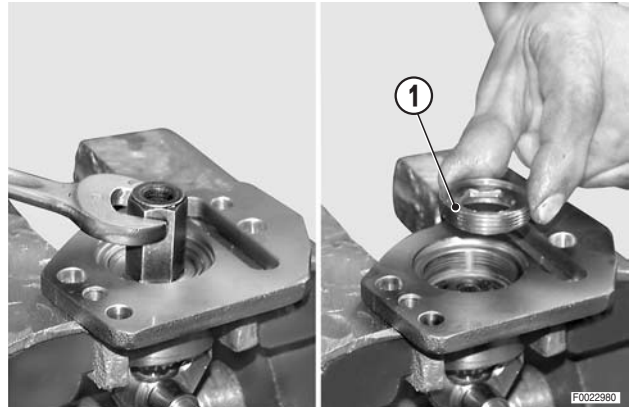


## 7. OVERHAUL OF THE MECHANICAL GOVERNOR DRIVE

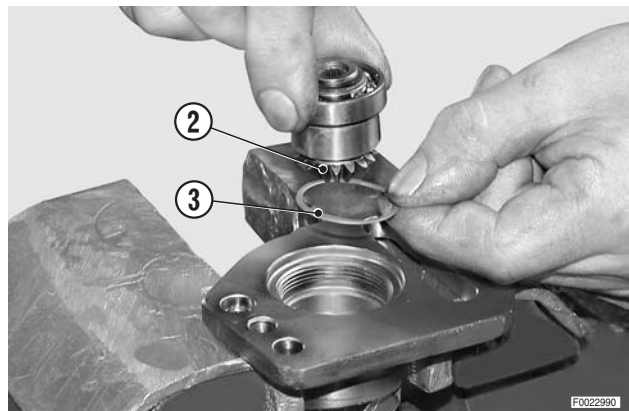
### 7.1 DISASSEMBLY

1 - Loosen and remove the ringnut (1).

- ★ The ringnut is staked to prevent it working loose; remove with care to avoid damaging the threads.

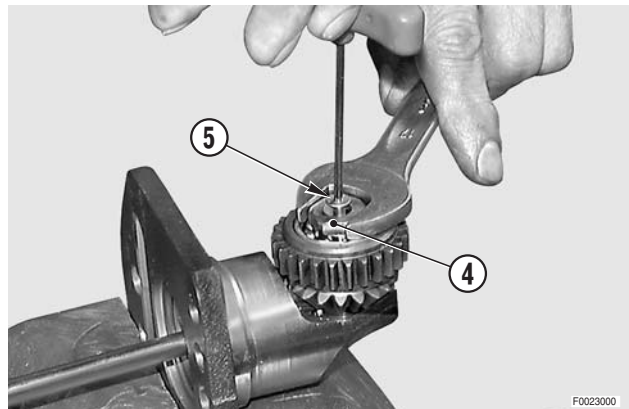


2 - Remove the driven gear assembly (2) and the spacer (3).

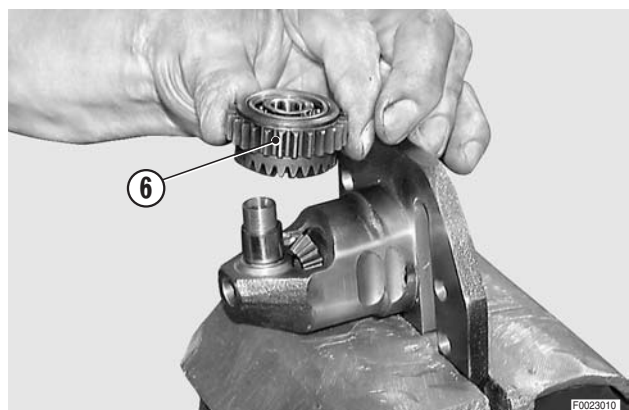


3 - While holding the adjustment screw (4), loosen and remove the central locking screw (5).

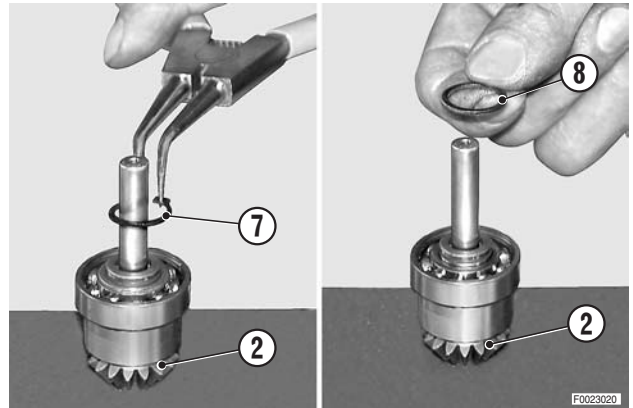
4 - Remove the adjustment screw (4).



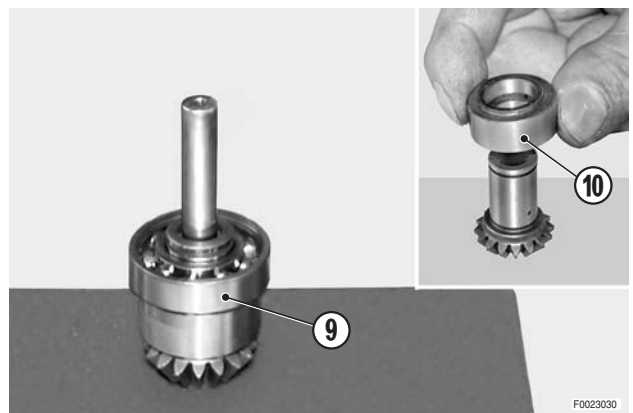
5 - Using a pulley, remove the driving gear (6).



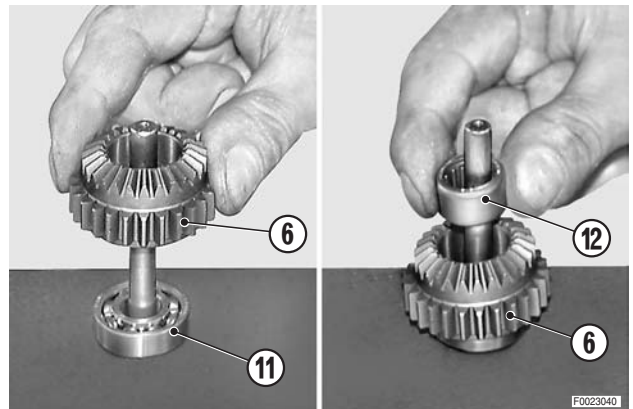
- 6 - Remove the circlip (7) and shim (8) from the driven gear (2).



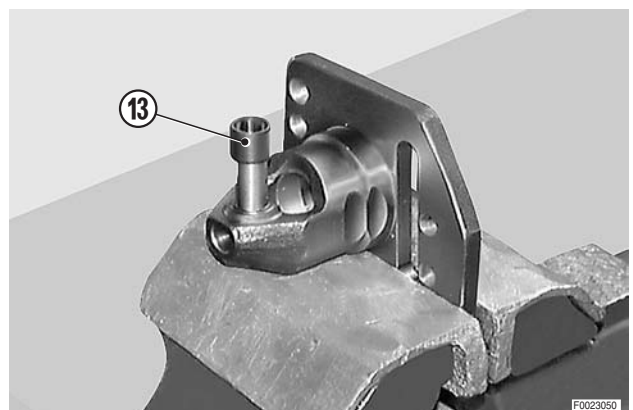
- 7 - Remove the bearing (9) and the spacer (10).  
★ Note which way round the spacer is installed.



- 8 - Remove the inner bearing (11) and the roller cage (12) from the driving gear.

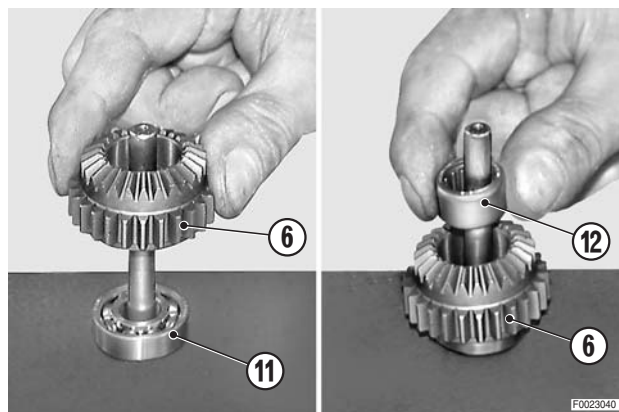


- 9 - Using a puller with thin arms, remove the inner race (13) of the roller cage from the shaft.

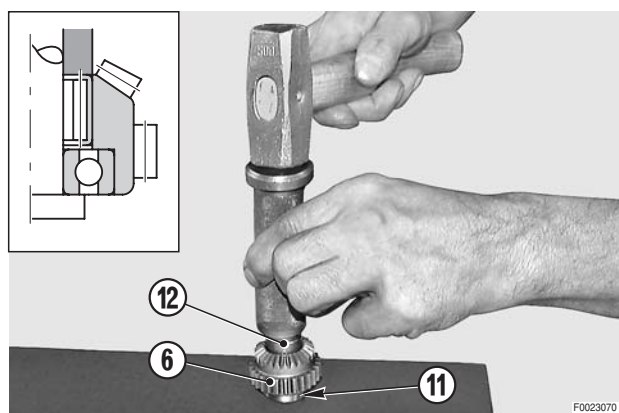


## 7.2 ASSEMBLY

- 1 - Position the bearing (11), the driving pinion (6) and the roller cage (12) on a guide pin.

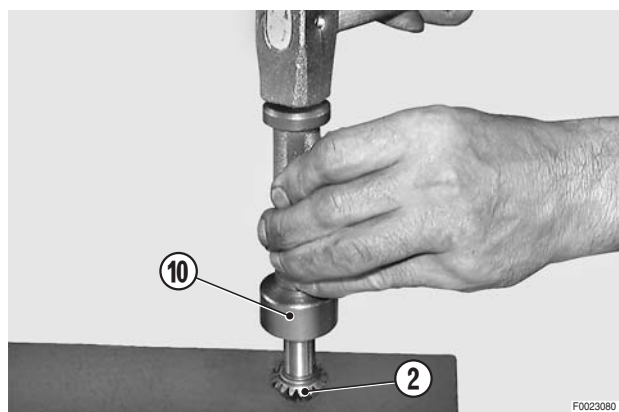


- 2 - Using a suitable drift, drive home the bearing (11) and the roller cage (12).



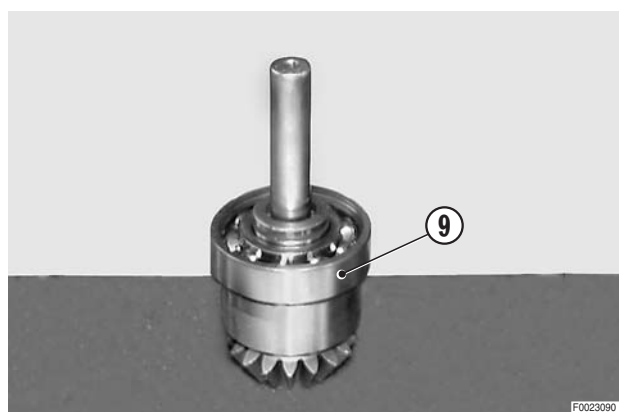
- 3 - Position the driven gear (2) on a guide pin, and using a suitable drift, drive the spacer home (10).

★ Check that the spacer is installed the right way round.



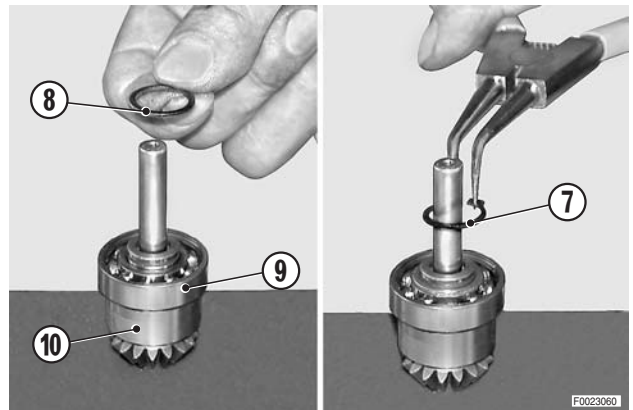
- 4 - Using the same drift, fit the bearing (9).

★ Check that the spacer and the bearing are pressed tight up together.



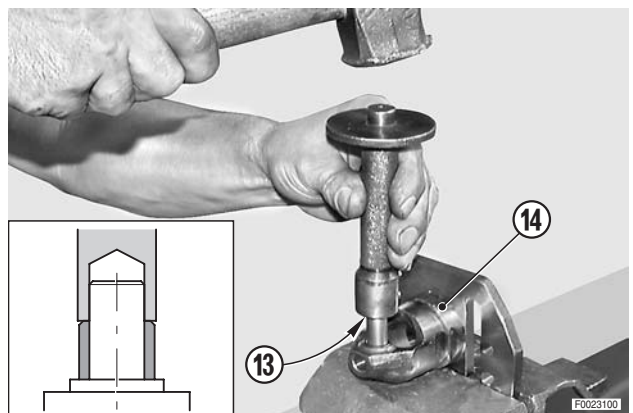


- 5 - Fix the position of the bearing (9) and the spacer (10) with the thrust washer (8) and the circlip (7).



- 6 - Using a suitable drift, fit inner race (13) of the roller cage on the pin (14).

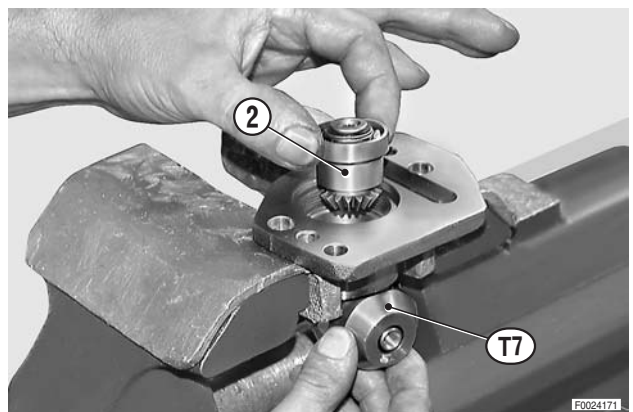
★ Take care to install the inner race the right way round.



- 7 - Fit tool **T7** (code 5.9030.887.0) on the pin and install the complete driven gear assembly (2).

★ Check that the gear (2) rests on tool **T7**.

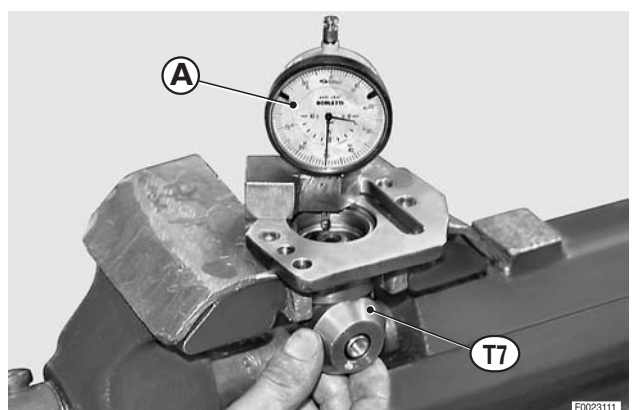
★ The tool has a recessed surface to facilitate positioning; after installation, rotate tool **T7** (code 5.9030.887.0) through about 180°.



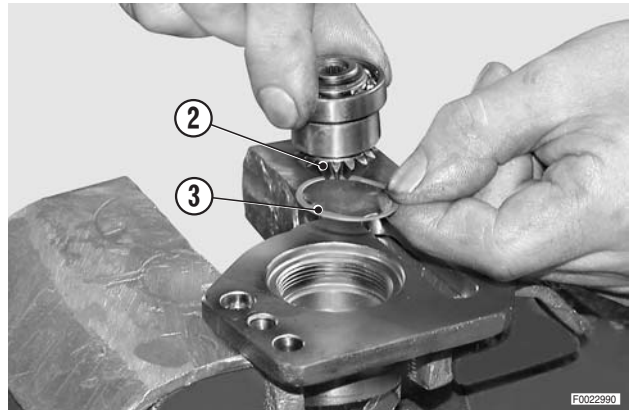
- 8 - Position a dial gauge "A" on the head of the gear (2) and preload the gauge by about 3 mm.

- 9 - Remove tool **T7** (code 5.9030.887.0) and press the gear assembly fully home in the support.

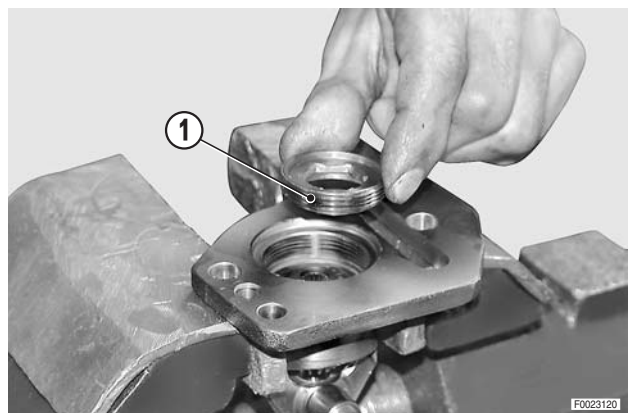
- 10 - Take the reading on the dial gauge to determine the thickness of the shims to install.



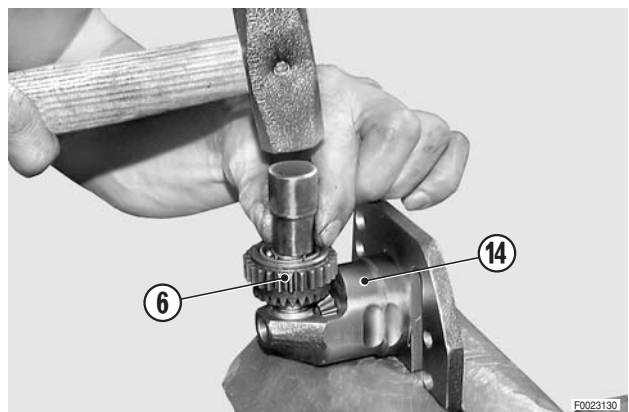
- 11 - Withdraw the driven gear (2) and fit shims of the measured thickness (3).



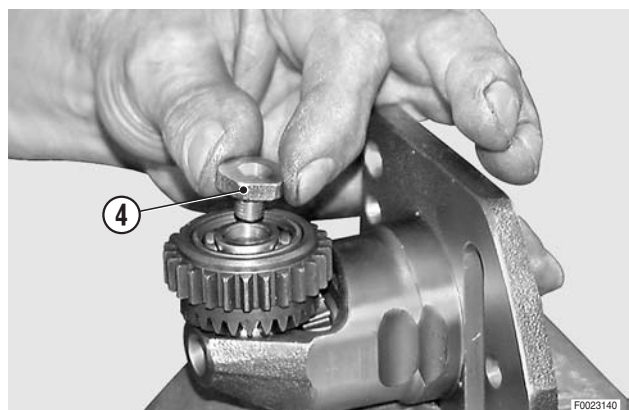
- 12 - Fit the driven gear (2) definitively and fix with the ring-nut (1).



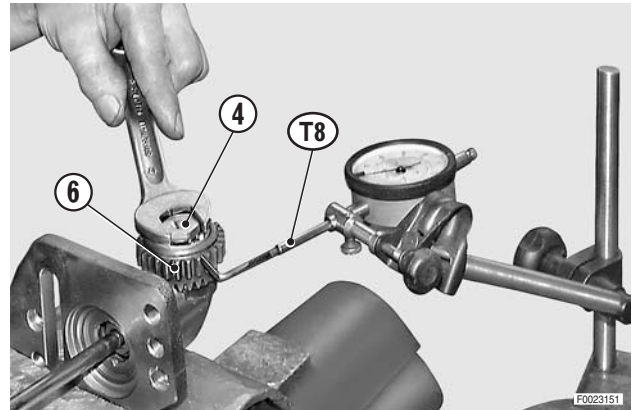
- 13 - Using a suitable drift, fit the driving gear (6) on the pin (14).  
★ The bearing must protrude about 3 mm relative to the shaft.




- 14 - Fit the adjustment screw (4) so that it touches the inner race of the bearing.

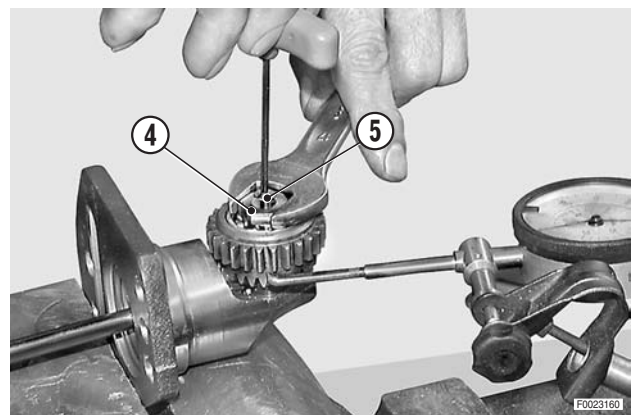


- 15 - Position a dial gauge with contact point **T8** (code 5.9030.888.0) resting on the side of the driving gear (6) and preload the gauge by about 2 mm.
- 16 - Tighten the adjustment screw (4) to obtain a tooth backlash of 0.03–0.08 mm.
  - ★ When measuring the backlash, rotate the driven gear in both directions (2).

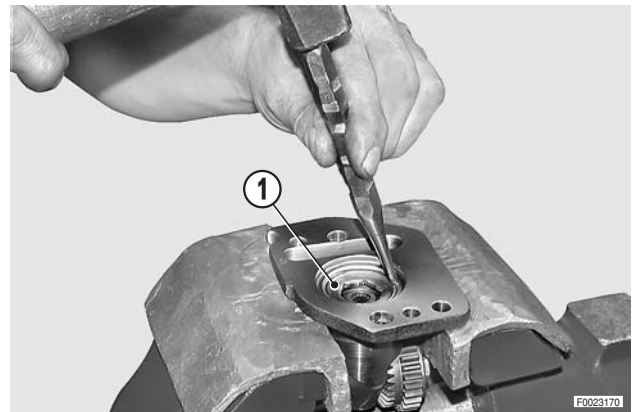


- 17 - While holding the adjustment screw (4) in position, screw in and tighten the stop screw (5) after applying threadlocking compound to the tip.

 Screw: Loctite 270



- 18 - Stake the ringnut (1) in three places (not in the same points as before).



## 8. OVERHAUL OF THE MECHANICAL GOVERNOR (STANDARD AND WITH L.D.A.)

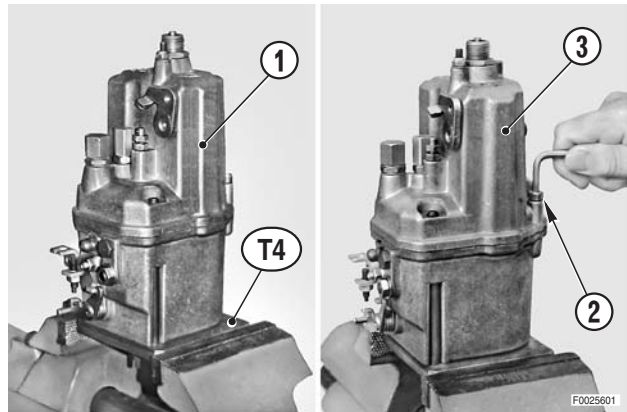


- 1 - Before overhaul, the governor must be removed from the engine and installed on tool **T4** (code 5.9030.665.0).
- 2 - The general adjustments that affect the operation of the governor must be made on the bench.
- 3 - Adjustments that affect the operation of the engine must be made with the governor installed on the engine.
- 4 - Only remove the parts indicated in this section; any parts not specifically mentioned should be left in the positions determined in the factory for the entire service life of the governor and engine.
- 5 - Should any of these factory-set parts be accidentally removed, the entire governor assembly must be sent to the factory for recalibration.

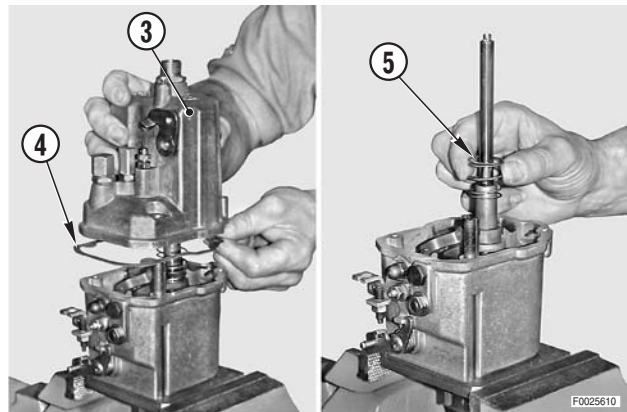
### 8.1. DISASSEMBLY OF THE STANDARD GOVERNOR

#### 8.1.1 Separation of the lower and upper housings

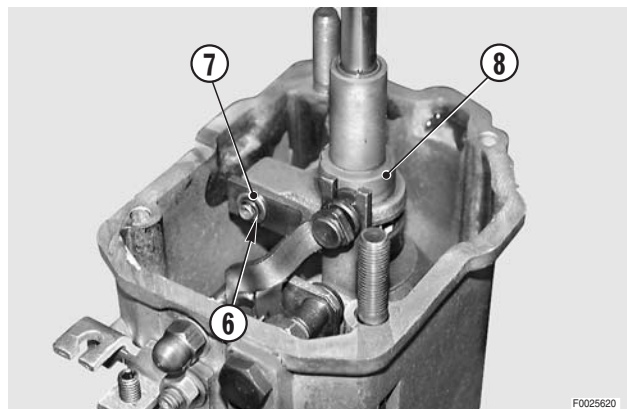
- 1 - Install the governor (1) on tool **T4** (code 5.9030.665.0) held in a vice.
- 2 - Loosen and remove the screws (2) securing the upper housing (3).



- 3 - Remove the upper housing (3) and the gasket (4).  
★ Fit a new gasket on reassembly.
- 4 - Remove the spring (5).

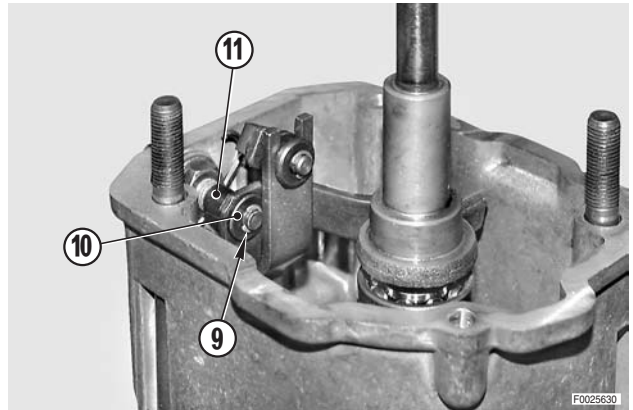


- 5 - Remove the circlip (6) and the washer (7) connecting the levers to the control sleeve (8).

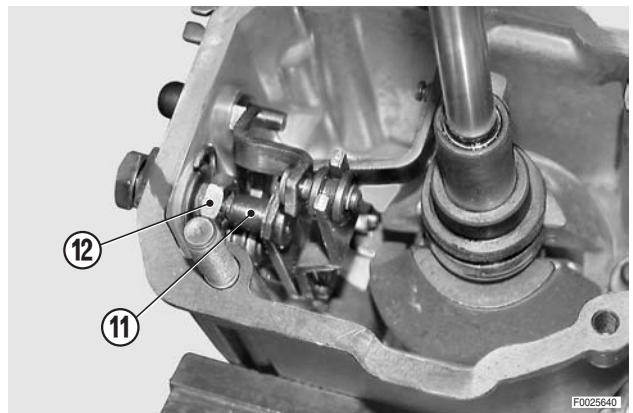




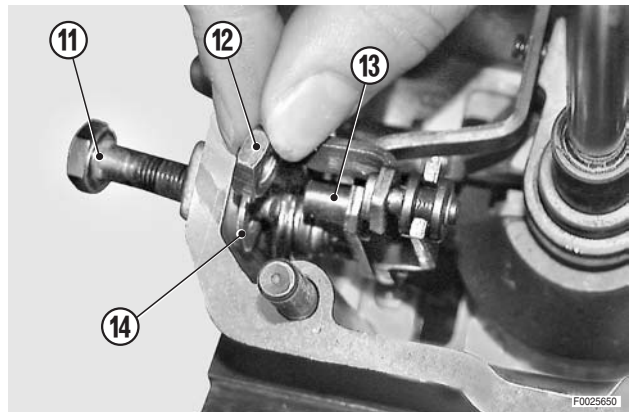
- 6 - Remove the circlip (9) and the washer (10) of the pivot pin (11).



- 7 - Loosen and partially unscrew the nut (12) securing the pivot pin (11).

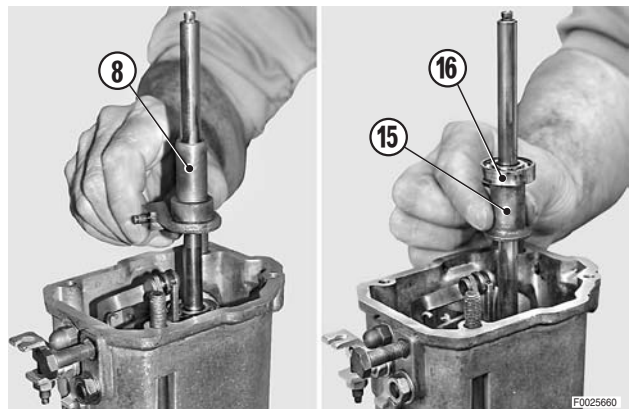


- 8 - Unscrew the pivot pin (11) from the outside so as to release the lever (13).  
★ Recover the nut (12) and the washer (14).  
★ Fit a new copper gasket.



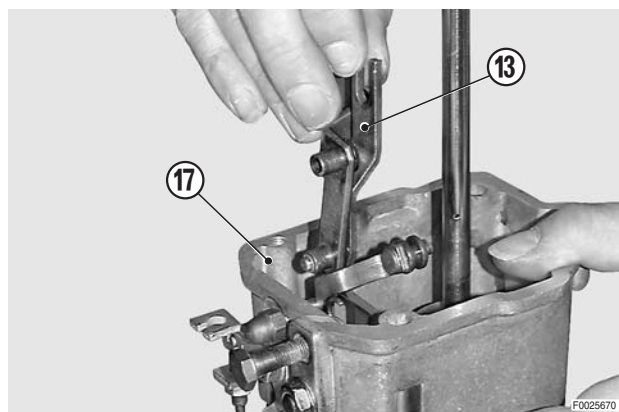
- 9 - Rotate the control sleeve (8) to detach it from the levers and remove it.

- 10 - Remove the thrust sleeve (15) complete with the bearing (16).





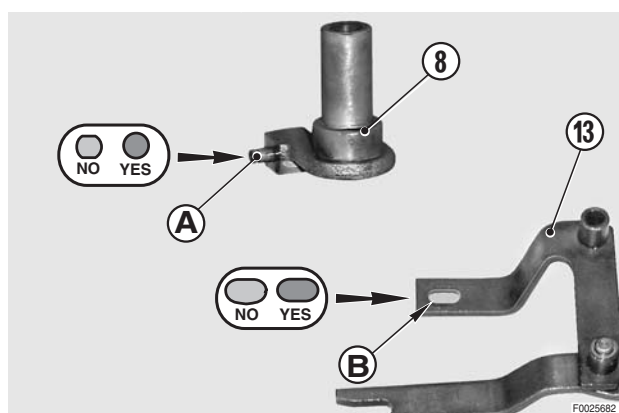
- 11 - Remove the lower housing (17) from tool **T4** (code 5.9030.665.0) and remove the levers assembly (13).



- 12 - Inspect the pin (A) on the sleeve (8) and the slot (B) in the lever (13).

If the pin is worn or the slot is concave, renew the parts concerned.

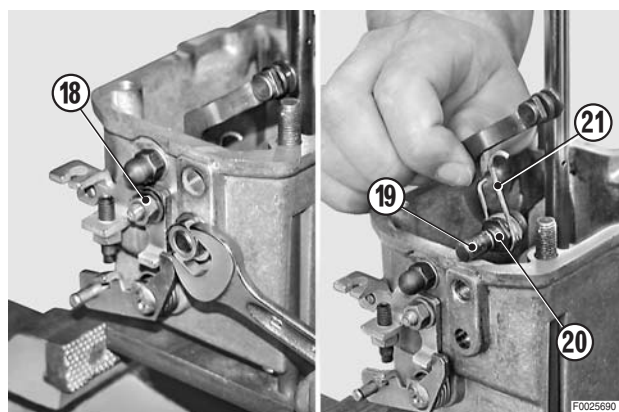
- ★ Eliminate any burrs that might have formed on the slot.



- 13 - Loosen and remove nut (18) with its washer.

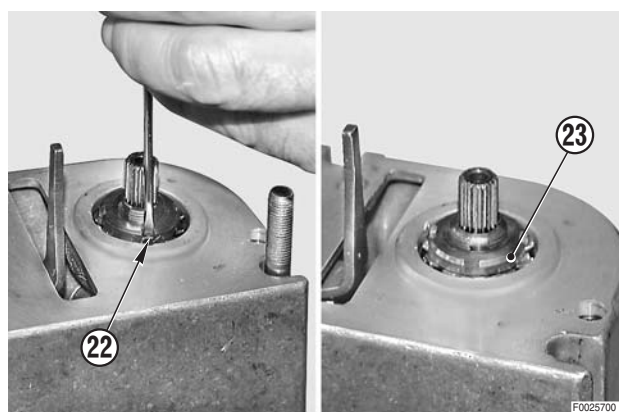
- 14 - At the same time, remove the spring pivot pin (19), bush (20) and spring (21).

- ★ Renew the O-ring.

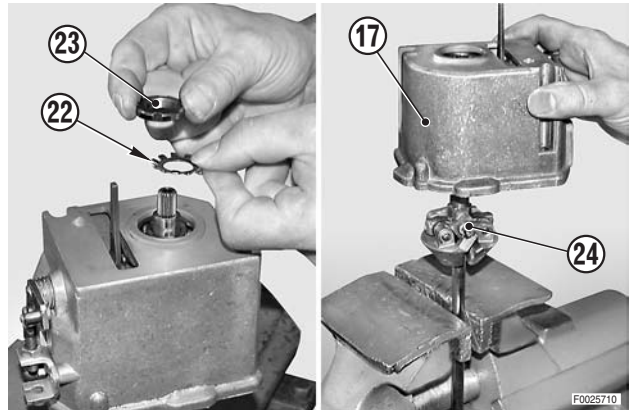


- 15 - Relieve the staking on the lock washer (22) and loosen the shaft lock nut (23).

※ 1

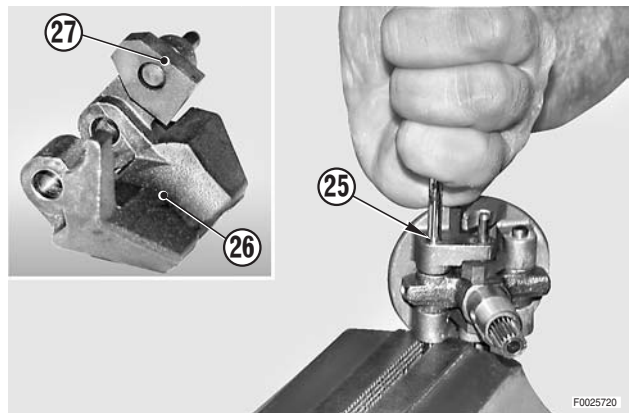


- 16 - Remove the ringnut (23), the lock washer (22) and withdraw the lower housing (17) from the shaft.



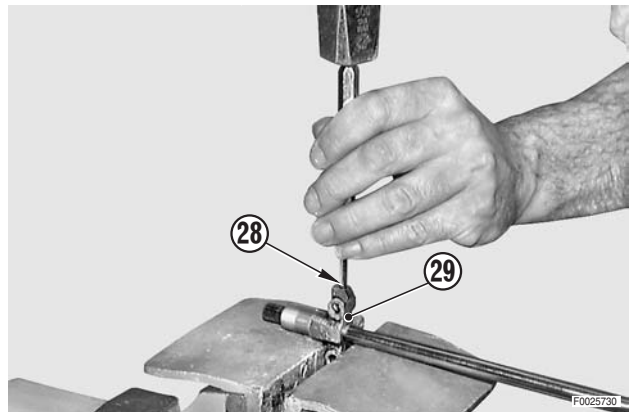
- 17 - Using a pin punch, withdraw the pivot pins (25) and remove the flyweights (26).

★ Note which way round the counter blocks are installed (27).



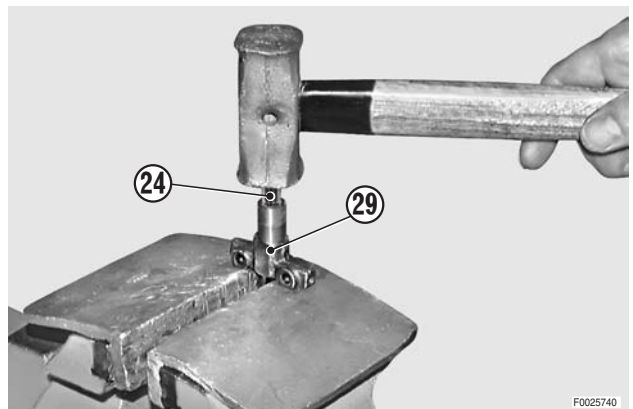
- 18 - Using a pin punch of suitable diameter, remove the spring pin (28) securing the flyweight support (29).

❖ 2

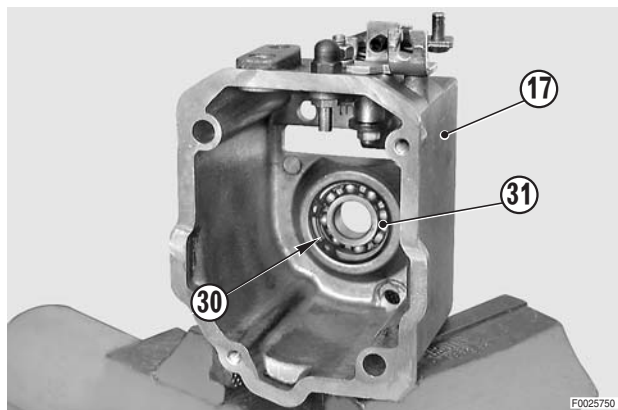


- 19 - Using a soft-face mallet (aluminium or copper), drive out the shaft (24) from the support (29).

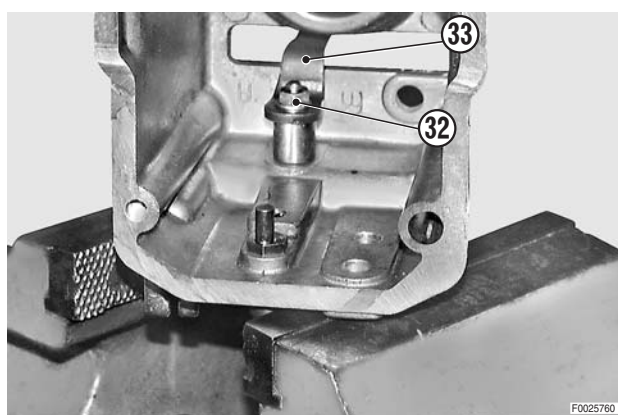
❖ 3



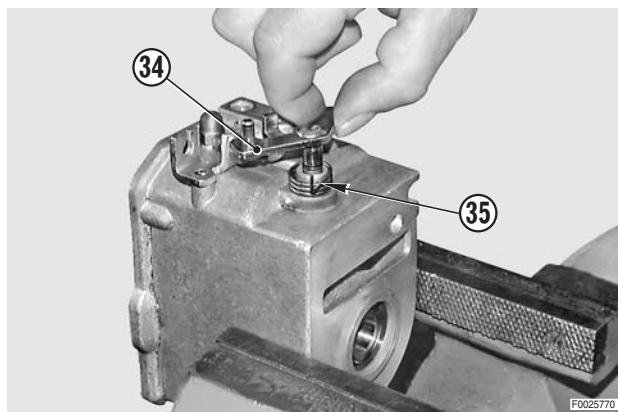
- 20 - Remove the circlip (30) and remove the bearing (31) from the lower housing (17).



- 21 - Loosen and remove nut (32) with its washer and remove the engine stop and automatic fuel increase lever (33).



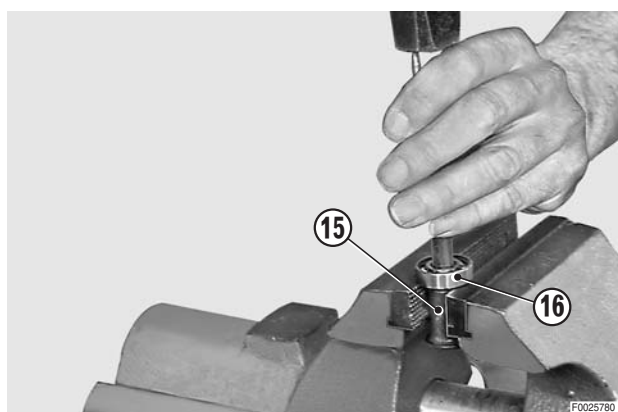
- 22 - Remove the engine stop lever (34) and the spring (35).  
★ Renew the O-ring.  
★ Note the positions of the ends of the springs.



- 23 - Using a drift of the same size as the inside diameter of the bearing, drive the bush (15) out of the bearing (16).

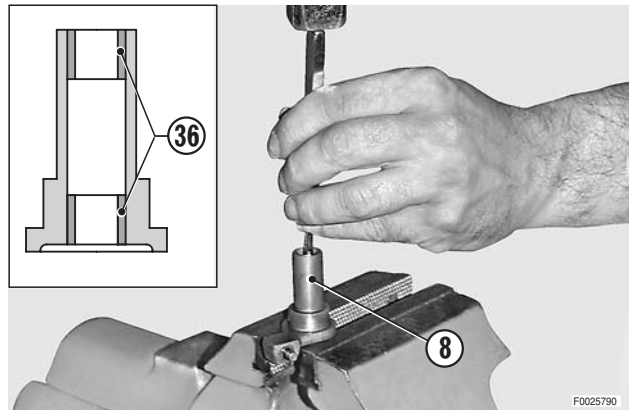
✕ 4

- ★ Recover any bearing adjustment shims.



24 - Using a suitable drift, remove the bushes (36) from the lever control sleeve (8).

- ★ Note that the bushes are installed flush with the sleeve.



### 8.1.2 Assembly of the lower housing

- Assembly is the reverse of disassembly.

✖ 1

- ★ Stake the lock washer.

✖ 2

- 🔧 Spring pin: Loctite 270

✖ 3

- 🔧 Shaft and support: Loctite 601

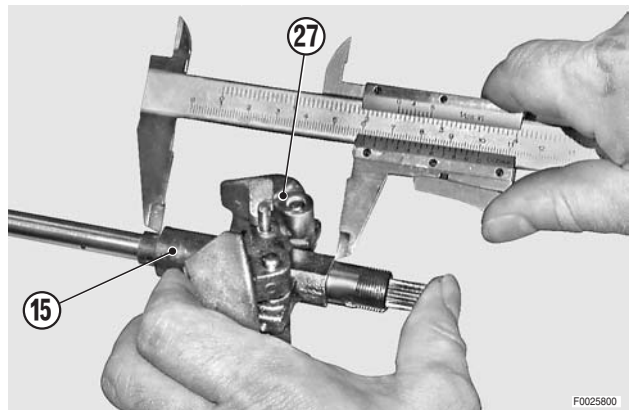
✖ 4

- ★ Calculate the thickness of the shims to be installed under the bearing as follows:

- 1 - Fit the sleeve (15) and, while holding it pushed against the contrast blocks (27), measure the distance between the bearing seats.  
Example: measurement 60.5 mm (2.384 in.)
- 2 - Subtract this measured dimension from the fixed design dimension to obtain the value “S” of the shim thickness to be installed under the bearing.

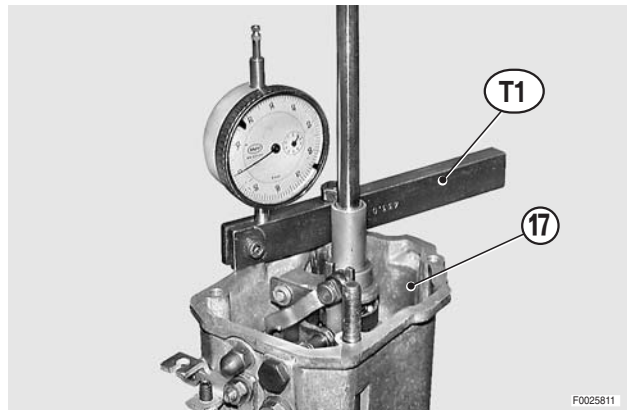
Fixed dimension:  $61 \pm 0.1$  (2.403  $\pm$  0.0039 in.)

$$S = 61 \pm 0.1 - 60.5 = 0.4 \text{ to } 0.6 \text{ mm}$$

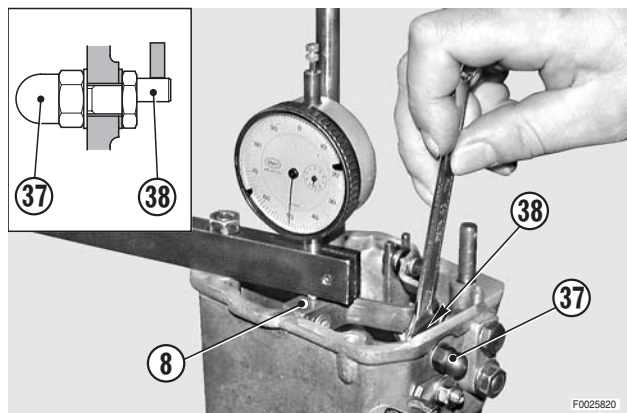


### 8.1.3 Adjusting the height of the lever control bush

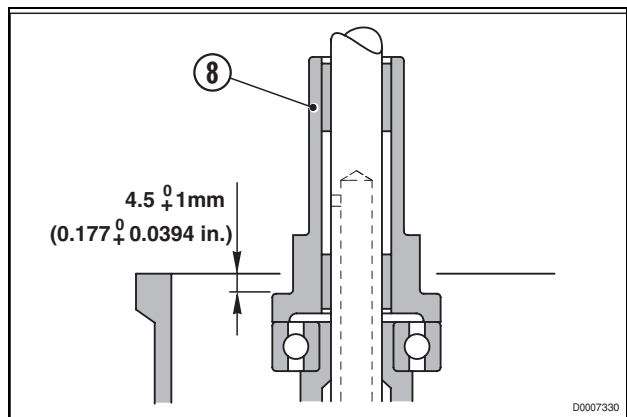
- 1 - Position the lower governor housing on tool **T4** (code 5.9030.665.0).
- 2 - Position a dial gauge in tool **T1** (code 5.9030.433.0) and fit the assembly on the stud; secure with a finger-tight nut.
- 3 - Preload the dial gauge by 5-6 mm (0.197–0.236 in.) on the face of the lower governor housing (17) and zero-set it.



- 4 - Loosen off the nut (37).
- 5 - Rotate the dial gauge tool so that the contact point rests on the face of the bush (8).
- 6 - Adjust the eccentric (38) to obtain the design dimension.
  - ★ Dimension  $4.5 \pm 1 \text{ mm}$  ( $0.177 \pm 0.039 \text{ in.}$ )
  - ★ Check that the eccentric is facing upwards.

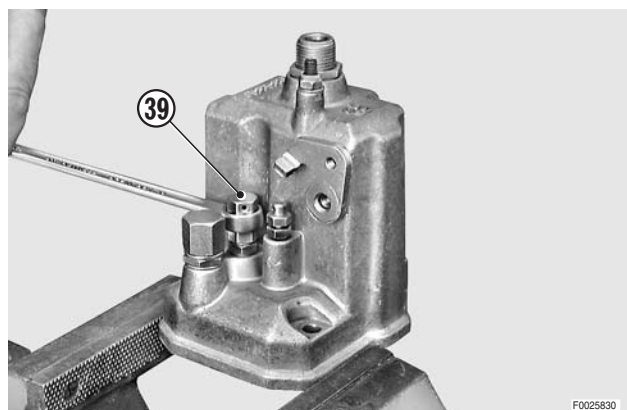


- 7 - While holding the eccentric (38) in position, tighten the nut (37).
- 8 - Repeat the check and, if necessary, repeat steps 6 and 7 to bring the dimension within the tolerance limits.



### 8.1.4 Disassembly of the upper housing

- 1 - After removing the tamper-proof seals, loosen and remove the safety cap (39) over the injector stroke adjustment screw. Remove also the copper gasket.

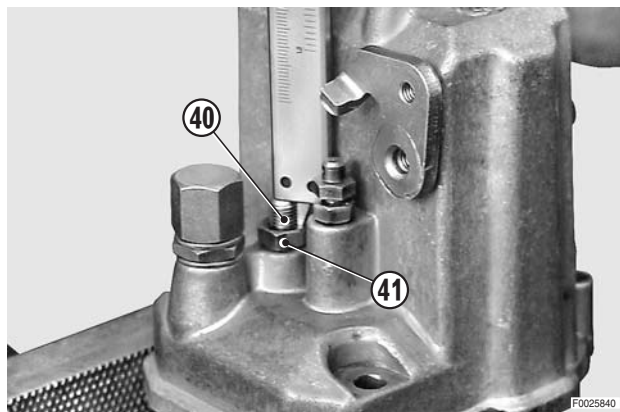




- 2 - Using a gauge, measure the protrusion of the screw (40) relative to the lock nut (41).

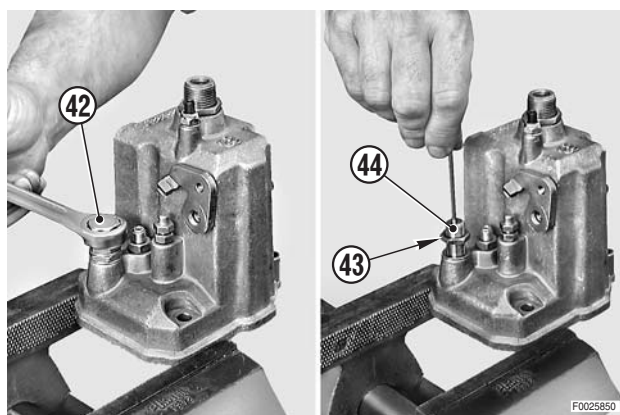
★ Make a note of this measurement, which must be restored on reassembly.  
The final measurement must be determined with the governor installed on the engine and the engine running.  
(For details see «8.4.2 GOVERNOR CALIBRATION»).

❖ 2



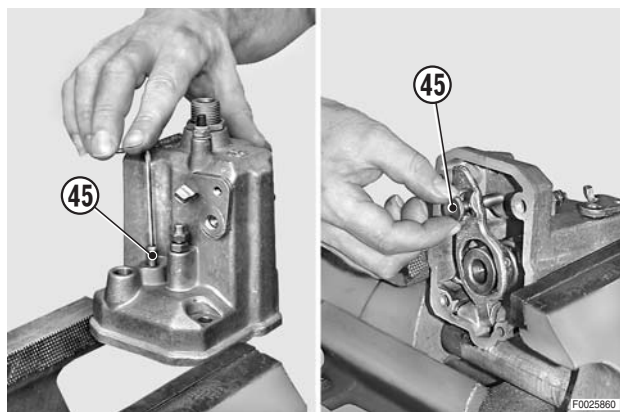
- 3 - Remove the cap (42) of the anti-hunting device and the copper gasket.

- 4 - Loosen the nut (43) and remove the anti-hunting device (44).



- 5 - Loosen and remove the control rod stroke lock nut and remove the screw (45).

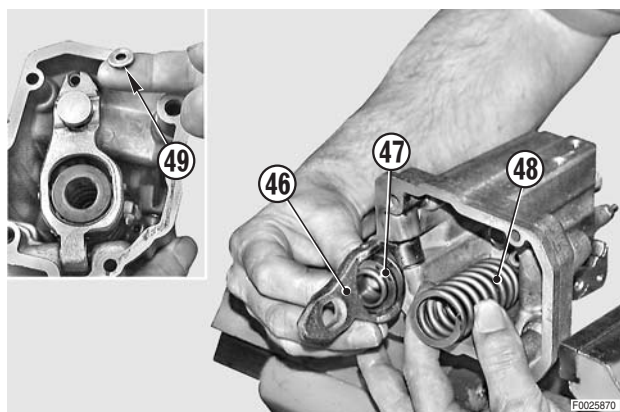
❖ 3



- 6 - Turn the lever (46) outwards and remove the bush (47) and the spring (48).

**For models with LDA only:** recover the washer (49) of the anti-hunting device spring

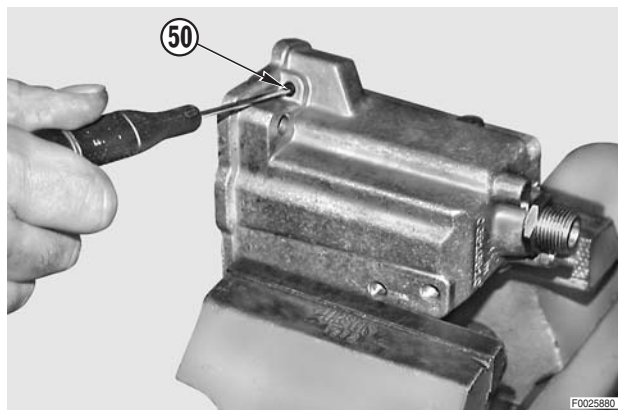
★ Note that the smaller diameter of the bush engages the spring.



7 - Loosen fully the lever pivot pin (50).

※ 4

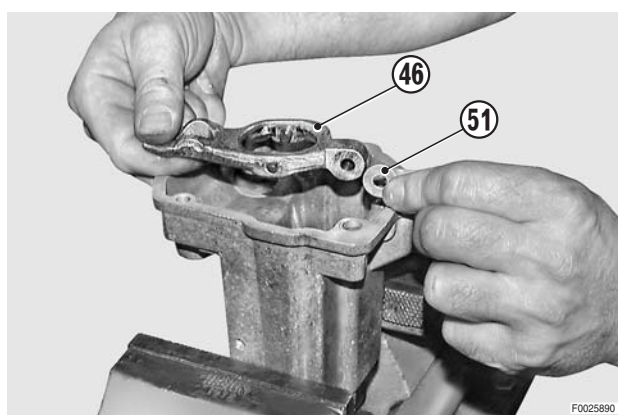
★ Renew the O-ring.



8 - Remove the pivot pin and remove the lever (46) with the two thrust washers (51).

★ Note that the thrust washers are installed on both sides of the lever pivot.

★ Check that the lever pins are perfectly cylindrical; renew them if even slightly out of round.

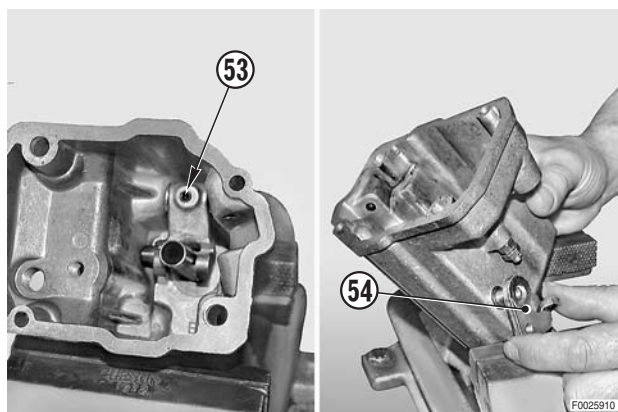


9 - Remove the spring guide bush (52).

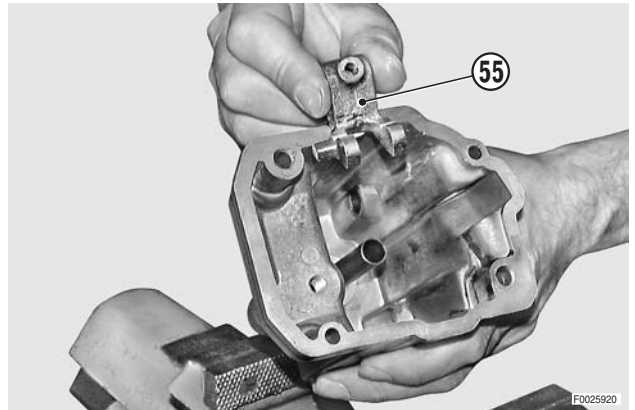


10 - Remove the grub screw (53) and remove the accelerator lever (54).

★ Renew the O-rings.

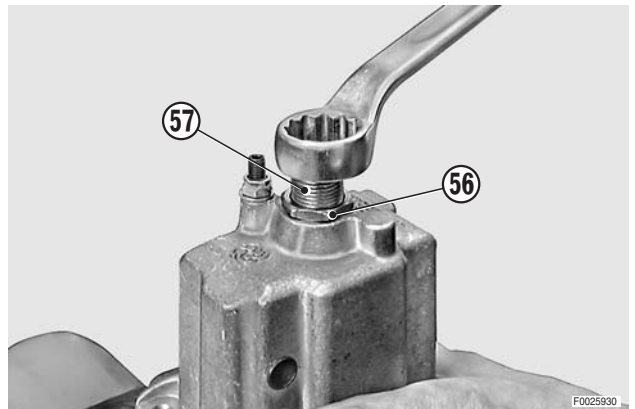


- 11 - Remove the fork (55) and the thrust washers (N. 2).
- ★ Note that the thrust washers are installed on both sides of the fork.



- ★ The following operations should be carried out:
  - 1 - On renewal of the flyweight shaft.
  - 2 - When the plain bearing and the shaft are worn.
  - 3 - When the sleeve and spring guide are worn or seized.
  - 4 - When the plain bearings of the accelerator lever are worn.
- ★ Even if the upper bush is not removed, renew the O-ring seal on reassembly.

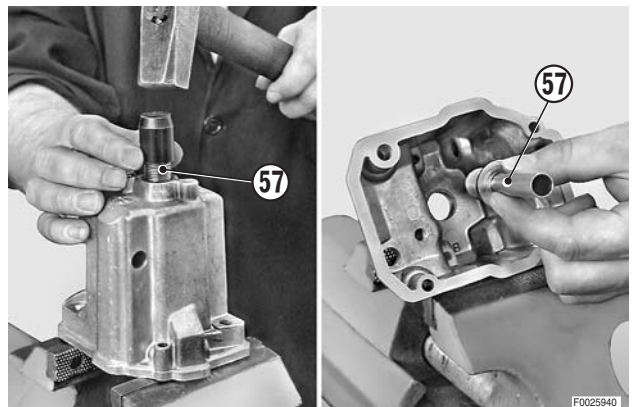
- 12 - Loosen and remove the lock nut (56) securing the upper guide bush (57).



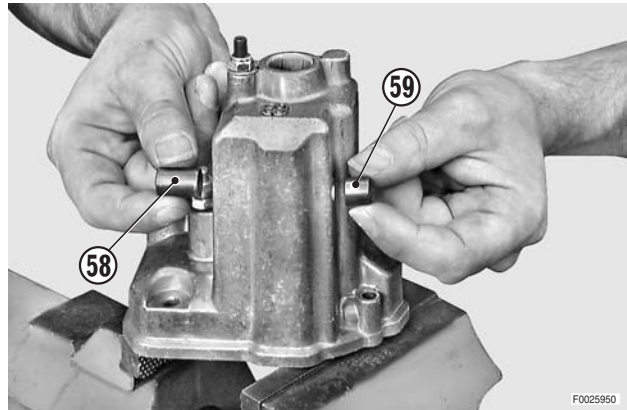
- 13 - Using a suitable drift, withdraw the guide bush (57).

⌘ 5

- ★ Always renew the O-ring.



- 14 - Renew the plain bearings (58) and (59) of the accelerator lever pivot pin. ✖ 6



### 8.1.5 Assembly of the upper housing

- ★ Assembly is the reverse of disassembly.

✖ 1

- ★ After the final calibration operations on the engine, affix the tamper-proof seals “C” and apply a touch of light coloured paint “D” to the adjustment screws.

✖ 2

- ★ Restore the correct protrusion of the injection stroke limit screw.

✖ 3

- ★ Screw the screw (45) into the upper housing to obtain a distance of approx. 1 mm (0.0394 in.) between the housing face and the head of the screw.

✖ 4

-  Pin thread: Loctite 242

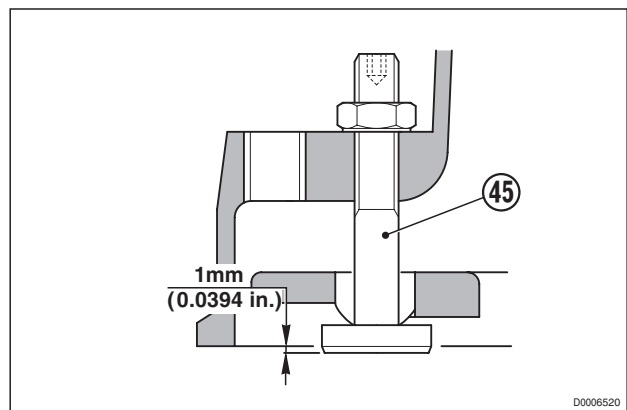
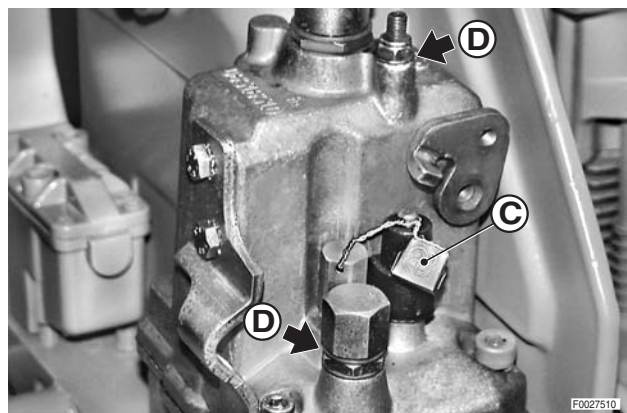
✖ 5

-  Bush: Loctite 601

✖ 6

-  Plain bearings: Loctite 601

- ★ Position the plain bearings flush with the inside face of the governor housing.



### 8.1.6 Assembly of the governor housing

- 1 - Lubricate the pivot points for all the levers and the weights in the lower housing.

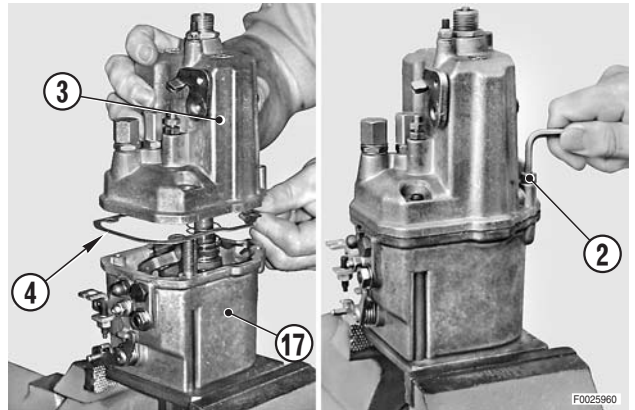
-  Pivot points: engine oil

- 2 - Lubricate the flyweight shaft, the bushes and all sliding elements.

-  Bushes and sliding elements: Molikote



- 3 - Position the gasket (4) on the lower housing (17) and fit the upper housing (3).
- 4 - Fix the two housings together with screws (2).
  - ★ Tighten the screws gradually in sequence.



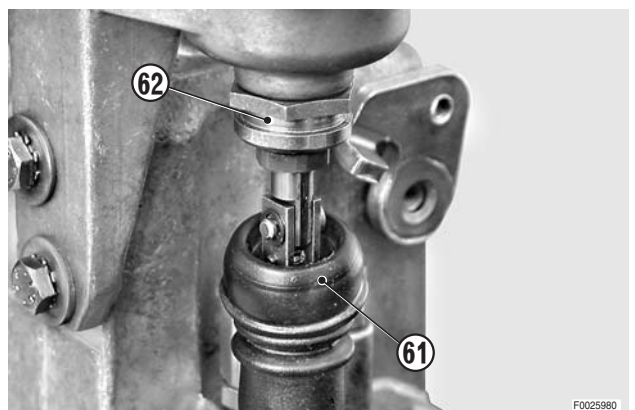
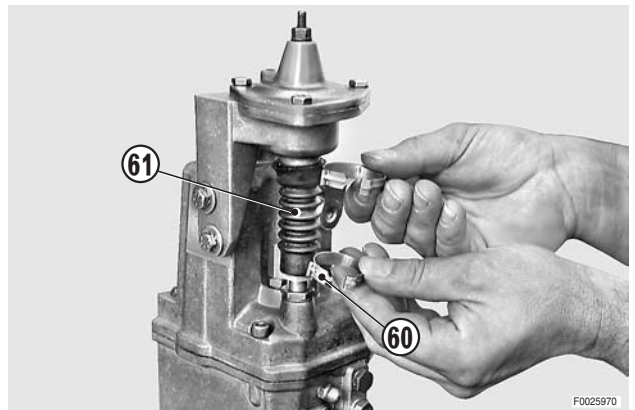
## 8.2 DISASSEMBLY OF THE GOVERNOR WITH L.D.A. VALVE



- 1 - Only operations that differ from those previously described for the standard version are described in this section.
- 2 - Although some components may differ in appearance from those of the standard governor, the descriptions and adjustments are the same unless otherwise specified.

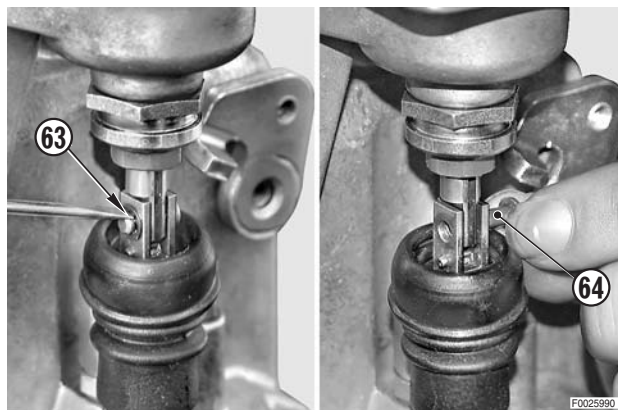
### 8.2.1 Separating the upper and lower housings

- 1 - Using the specific pliers, remove the clamps (60) securing the rubber covers (61).
- 2 - Release the cover (61) from the bush (62) and push it downwards.





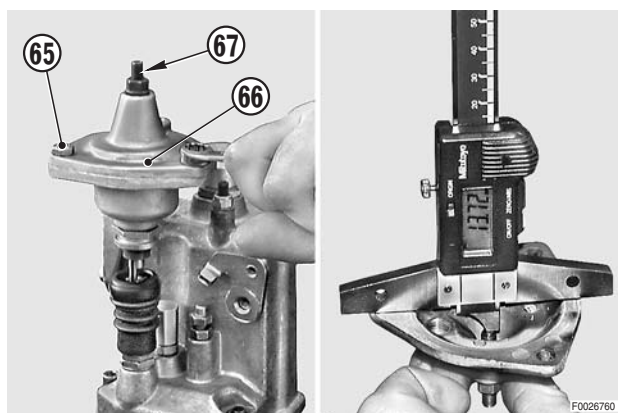
- 3 - Remove the circlip (63) and withdraw the pin (64).



### 8.2.2 Renewal of the membrane

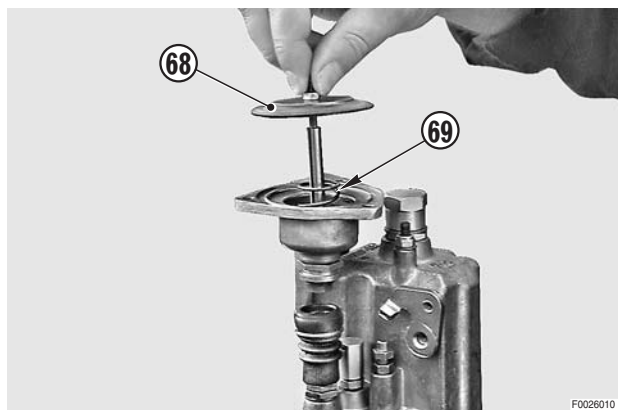
- 4 - Loosen and remove the screws (65); remove the valve cover (66).

**!** The grub screw (67) must not be removed, but adjusted, if necessary, during governor calibration. (For details see «8.3.3 Adjustment of the membrane travel»).

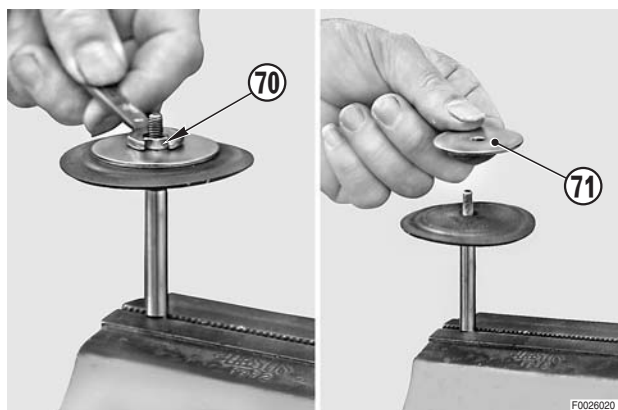


- 5 - Remove the membrane assembly (68) and the spring (69).

★ Recover any shims located under the spring.



- 6 - Hold the membrane unit in vice. Loosen and remove the nut (70) and upper plate (71).

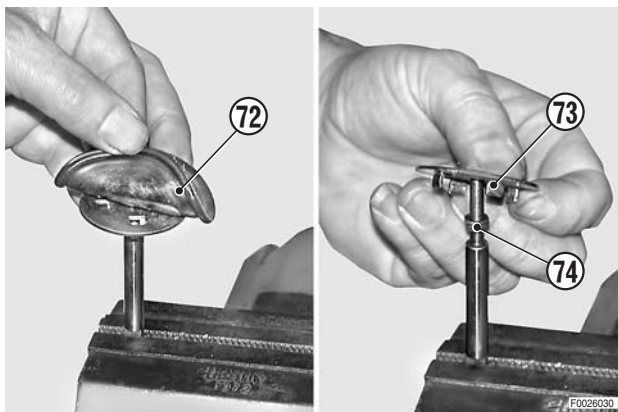


- 7 - Remove the membrane (72).

★ Note which way round the membrane is installed.

- 8 - Raise the guide plate (73) and tighten the nut (74) by about 2 turns.

⚠ This operation is to be carried out **only** when it is necessary to check that the membrane stroke is centred correctly; in the case of renewal only, this operation is not necessary **because the position of the lower nut (74) does not change**.

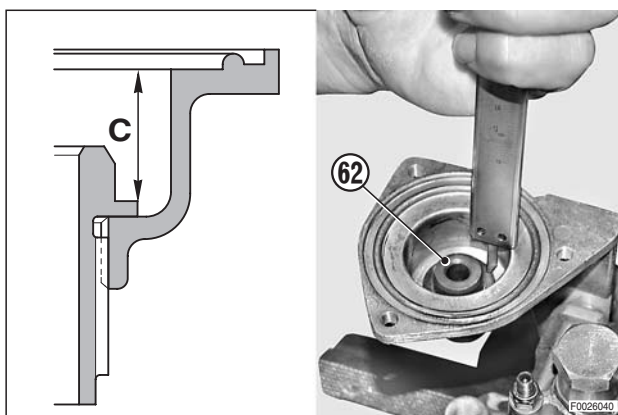


### 8.2.3 Completion of the disassembly

- 9 - **Only in the case of renewal of the membrane guide bush or the valve body:** measure the distance "C" between the surface of the guide disc and the face of the spring support bush (62).

※ 1

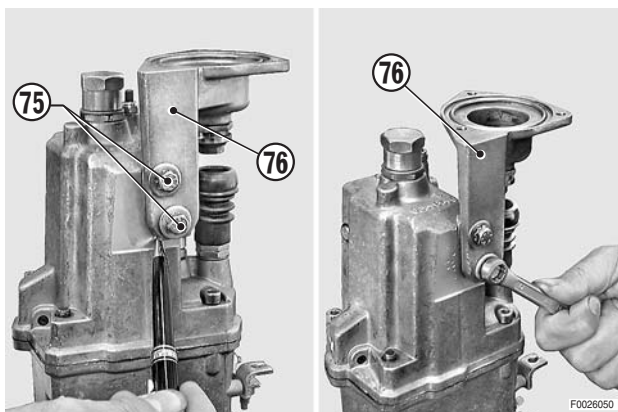
⚠ Make a note of this distance, which must be restored on reassembly.



- 10 - **Only in the case of renewal of the valve body:** mark the position of the L.D.A. valve body on the upper governor housing and remove the screws (75) and valve body (76).

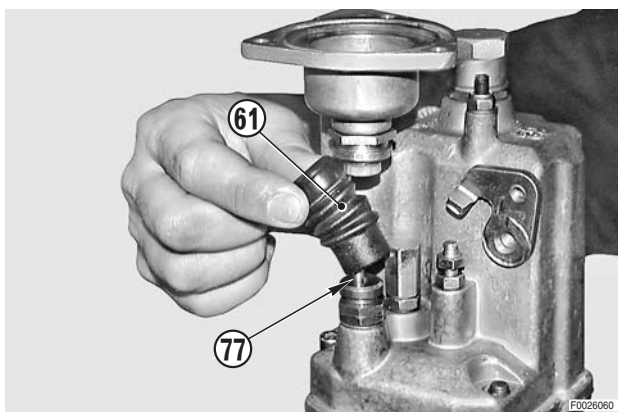
※ 2

★ **Only where present:** mark the positions of any shims installed between the valve body and the governor housing to avoid confusion on reassembly.



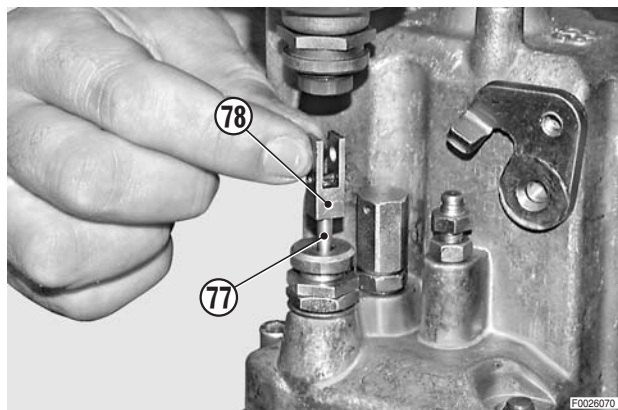
- 11 - Remove the gaiter (61).

★ Take care not to deform the rod (77) controlling the stroke of the injection pump control rod.

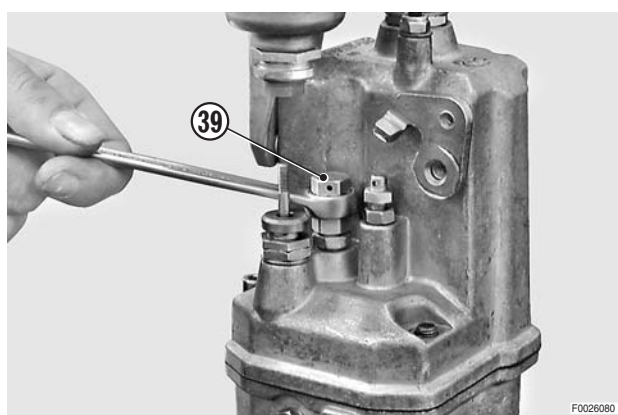


- 12 - Unscrew and remove the membrane connection fork (78).

✖ 3



- 13 - After removal of the tamper-proof seals, loosen and remove the safety cap (39) over the injector control rod stroke adjustment screw. Remove also the copper gasket.

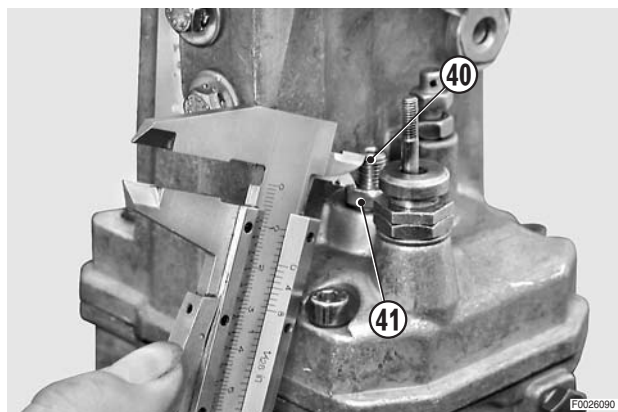


- 14 - With a gauge, measure the protrusion of the bolt (40) relative to the lock nut (41).

✖ 4

- ★ Make a note of the measurement, as this must be restored during reassembly in order to keep the engine running.
- The final measurement is determined with the governor installed and the engine running.
- (For details see «8.4.2 CALIBRATION OF THE GOVERNOR»).

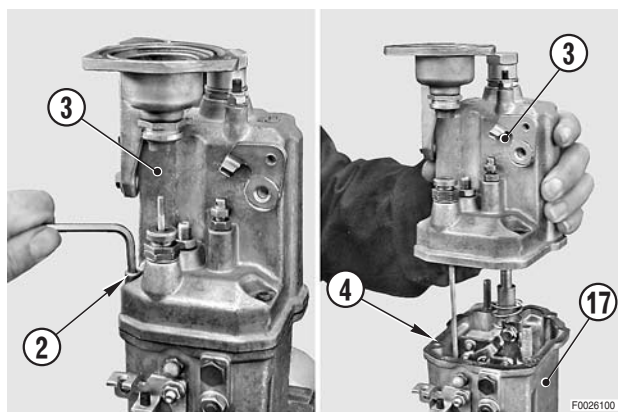
- 15 - After taking the measurement, remove the nut (41).



- 16 - Loosen and remove the screws (2) joining the upper (3) and lower (17) housings of the governor.

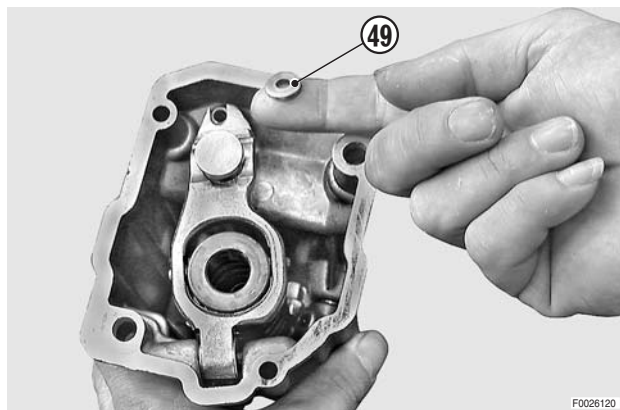
- 17 - Remove the complete upper housing (3) and the gasket (4).

- ★ Fit a new gasket on reassembly.

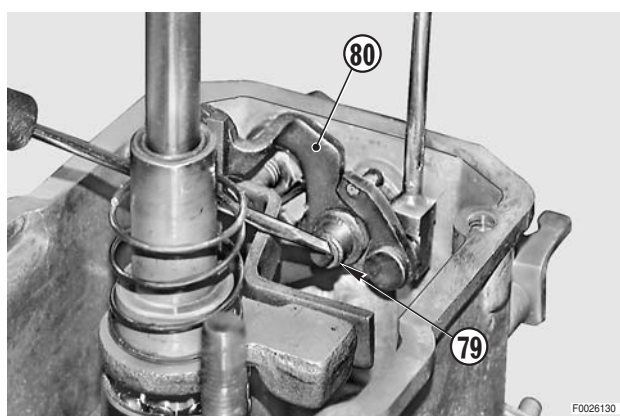


- 18 - Recover the washer (49) that supports the anti-hunting spring.

※ 5



- 19 - Remove the circlip (79) securing the lever (80) that controls the stroke of the pump control rod.
- 20 - Remove the complete lever (80).
- 21 - Proceed with total disassembly of the upper and lower housings as described for the standard governor. (For details see «8. OVERHAUL OF THE MECHANICAL GOVERNOR»).



#### 8.2.4 Assembly of the governor with L.D.A. valve

- Assembly is the reverse of disassembly

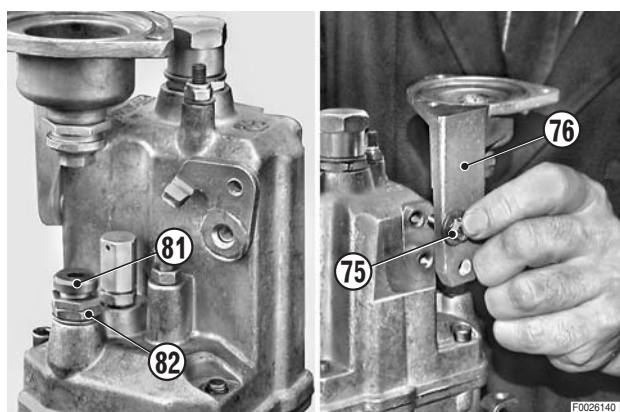
※ 1

- ★ Restore the previous measurement before installing any shims.

※ 2

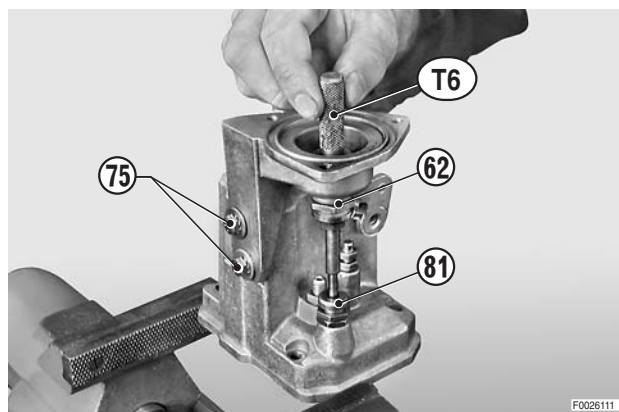
- ★ Centre the valve body as follows:

- 1 - Fit the bush (81) of the anti-hunting device and fix it by slightly tightening the locknut (82).
- 2 - Fit the L.D.A. valve body (76) to the upper governor housing, installing any shims that were previously removed; loosely fix the valve body with the screws and washers (75).

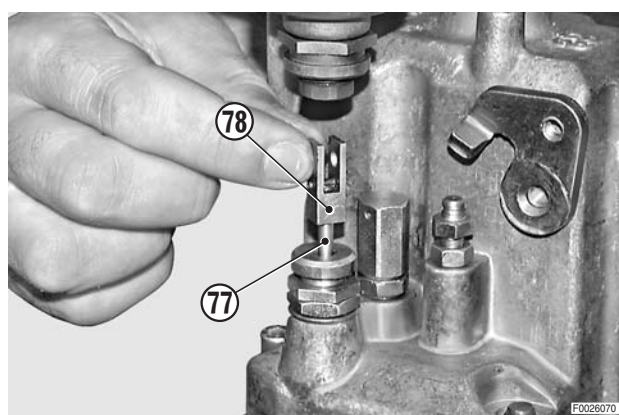




- 3 - Insert tool **T6** (code 5.9030.885.0) into the hole in the membrane rod guide bush (62) and the hole of the anti-hunting bush (81); and further tighten screws (75). Check that the tool slides freely and finally tighten alternate screws in sequence.

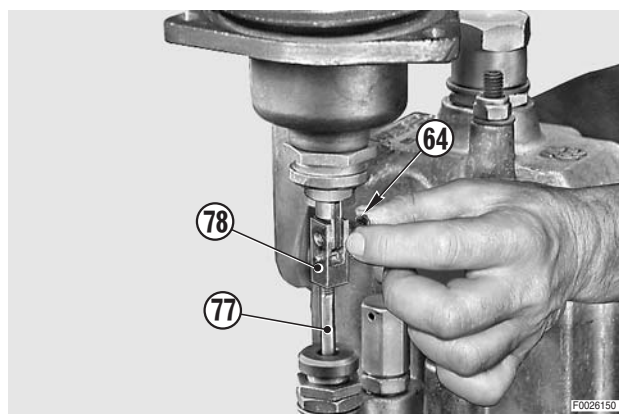


- 4 - Join the upper and lower governor housings and screw the fork (78) onto the rod (77).



#### 8.2.4.1 Checking

- 5 - Temporarily fit the complete membrane and connect the rod (77) to the fork (78) using pin (64).
- 6 - Lift the membrane and check that the movement is smooth and even over the entire stroke. If necessary, alter the position of the valve body to eliminate any friction.
- 7 - Disconnect the rod to carry out adjustments on the bench and to complete the assembly procedure. (For details, see the following paragraph).



#### ✧ 3

- ★ Check that the fork is screwed in so that it rests on the spring pin.

#### ✧ 4

- ★ Restore the previous measurement.

#### ✧ 5

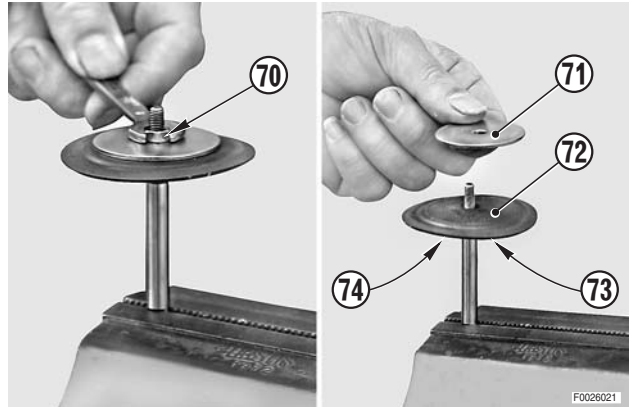
- ★ To hold the washer in position, coat it with a little grease.



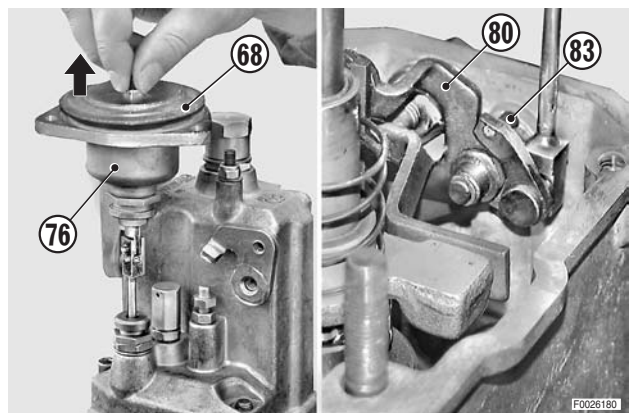
### 8.3 BENCH ADJUSTMENT OF L.D.A. VALVE

#### 8.3.1 Adjusting the length of the tie-rod

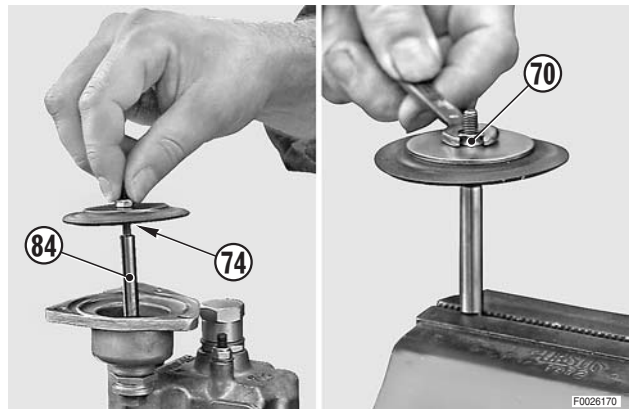
- 1 - Before fitting the upper cover, loosen and remove the nut (70), membrane (72) and the two plates (71), (73).
- 2 - Screw the lower nut (74) onto the guide rod by a few turns; reposition the plates, membrane and nut (70).



- 3 - Pull the membrane (68) upwards until you feel pin (83) contacts lever (80).
- 4 - Screw in nut (70) so that the lower plate (73) rests on the valve body (76).

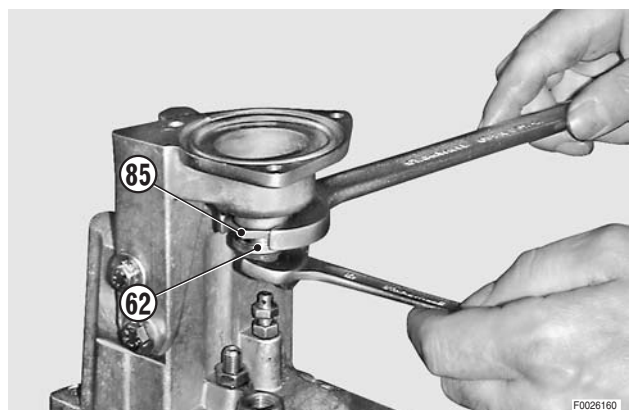


- 5 - Remove the pin (84) and withdraw the membrane assembly without moving the nut (74).
- 6 - Screw the nut (74) up to the lower plate (73) then back it off by a half turn.
- 7 - While holding the lower nut in position (74), tighten the nut (70).



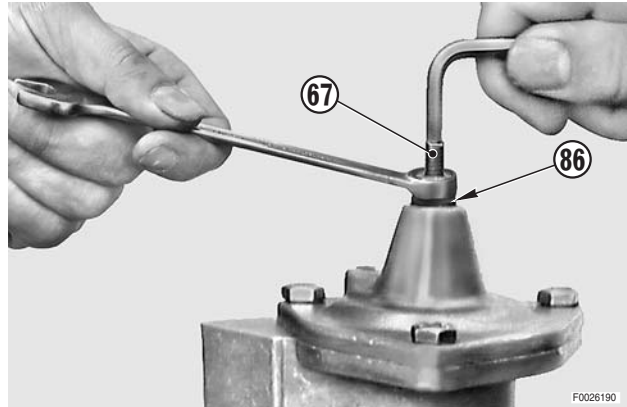
#### 8.3.2 Adjusting the spring load

- 1 - Loosen the ring nut (85) and screw out the bush (62) up against the valve body.
- 2 - Screw in the bush (62) by 3/4 of a turn and lock with ring nut (85).
- 3 - Complete the assembly of the valve and the governor.



### 8.3.3 Adjusting the membrane travel

- 1 - With the valve fully fitted, screw in the adjuster screw (67) until the lower guide plate is pushed against the valve body.
- 2 - Unscrew the grub screw (67) by 2 1/4 turns and fix in this position with nut (86).

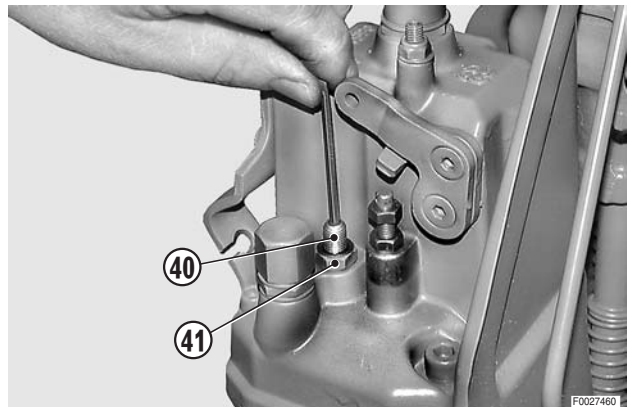


## 8.4 FINAL ADJUSTMENTS

- !** 1 - If the engine is installed on a vehicle, the adjustments must be carried out in conditions of safety, with the vehicle on a level surface and the parking brake on.
- 2 - The adjustments described in this paragraph must be carried out with the governor installed on the engine and, in the case of the mechanical governor, with all the external controls connected and adjusted.
  - 3 - Make the final adjustments after allowing the engine to run to bring the oil temperature up to at least 80 °C (176 °F)
  - 4 - Adjustments must be made without any load on the engine, i.e with air conditioning, heating, lights and control valves switched off.

### 8.4.1 Adjusting the fuel flow rate

- 1 - With the engine at normal operating temperature, operate the hand throttle to bring it up to calibration speed.  
★ Calibration speed: see table 3.4.2.
- 2 - Loosen the lock nut (40) securing the power adjuster screw (41) and unscrew the adjuster screw to the point where the engine almost stalls (300 to 500 rpm.).
- 3 - Screw in the screw (41) by about 3 turns and wait for the engine speed to stabilise.
- 4 - Back off the screw (41) by two full turns and then in steps of 30° a time with pauses of about 5 seconds between each step.
- 5 - Continue turning the screw until the engine stops.
- 6 - With the engine stop, screw the power adjustment screw (41) by the amount specified in the table 8.4.2, for the engine type stamped on the engine identification plate.



#### Example:

Engine type indicated on identification plate: 1000.3 AT2  
Screw turns: n° 6.25

**NOTE** - Screw turns are given in full and quarter turns.

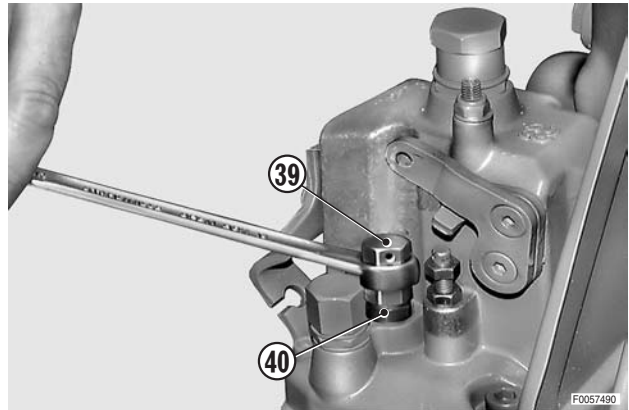
## 8.4.2 Calibration for mechanical governors

Engine type	Rated power kW (hp)	Engine speed		
		Minimum rpm $\pm$ 20	Maximum (without load) rpm ( $\pm$ )	Speed at max. power rpm $\pm$ 5



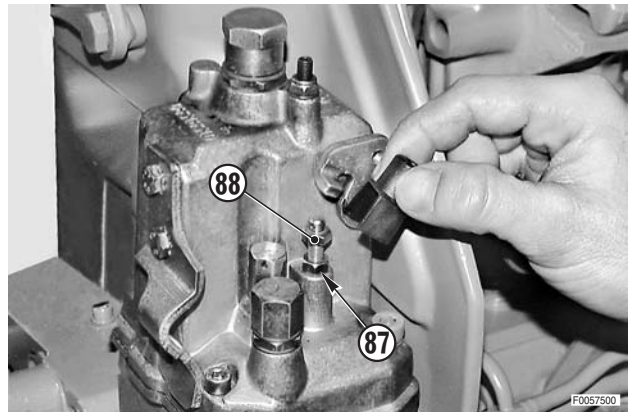
**THE VALUES FOR THIS PAGE SHALL BE SUPPLIED  
WITH THE NEXT UPDATES**

- 7 - While holding screw (41) in position, tighten nut (40).
- 8 - Fit the safety cap (39) and secure with nut (40).



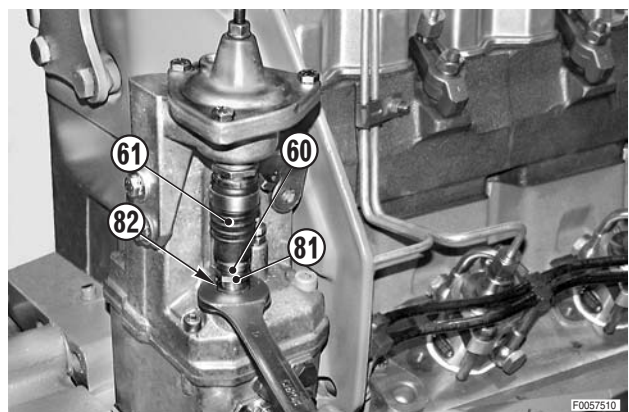
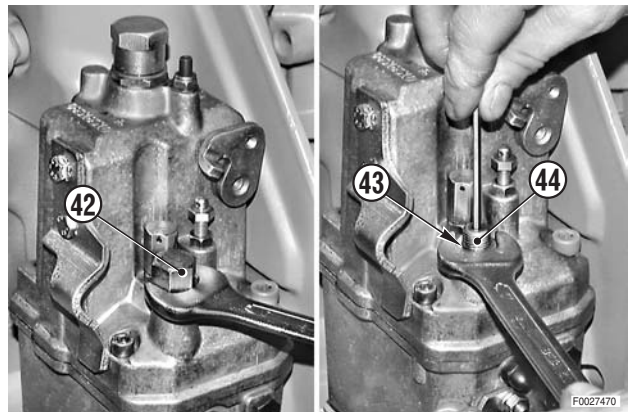
### 8.4.3 Adjusting the maximum speed

- 1 - Loosen the nut (87) and adjust the maximum speed as specified in the calibration table by turning the adjuster screw (88).
  - ★ Check the speed using an accurate tachometer.
- 2 - While holding the screw (88) in position, tighten nut (87).
- 3 - Apply the tamper-proof seal.



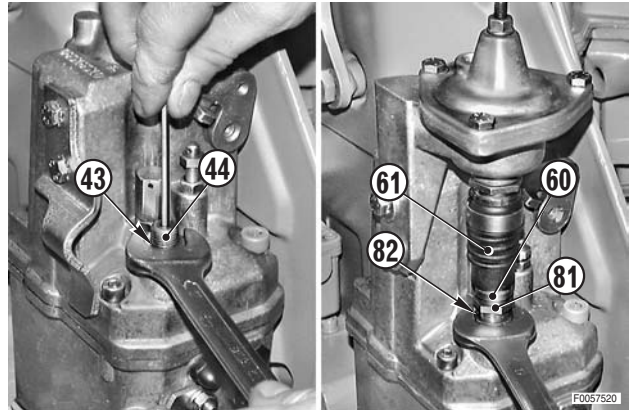
### 8.4.4 Hunting adjustment

- 1 - **For standard governor only:** remove the safety cap (42).
- 2 - **For standard governor only:** loosen nut (43) and unscrew the adjuster screw (44) by several turns.
- 3 - **For governors with L.D.A. valve:** remove the clamp (60) and lift the rubber cover (61).
- 4 - Loosen the nut (82) and unscrew the bush (81) by several turns.



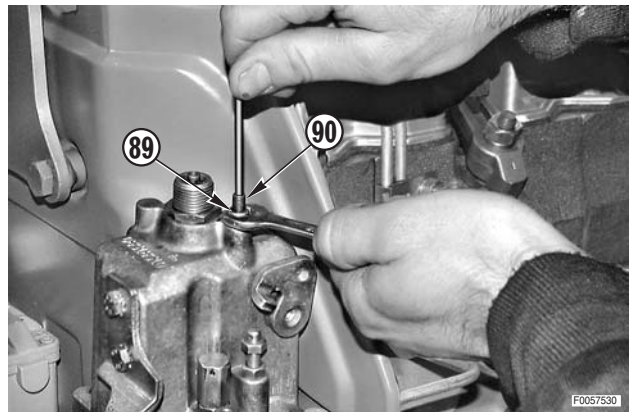


- 3 - Start the engine and take it to the maximum speed without load.
- 4 - Slowly screw in the bush (81) or adjuster screw (44) until hunting is reduced.
  - ⚠ 1 - Adjustment can only limit hunting, it cannot completely eliminate it.
  - 2 - The adjustment must not alter the maximum engine speed by more than 20 rpm.
  - 3 - Check the engine speed using a precision tachometer.
- 5 - While holding the bush (81) or adjuster screw (44) in position, tighten nut (43) or (82).
- 6 - Stop the engine and fit the safety cap.
  - ★ For governors with L.D.A. valve, replace the rubber cap (61) and attach the clamp (60).



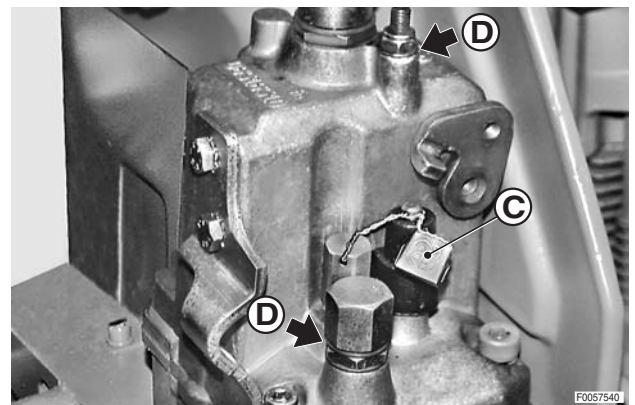
#### 8.4.5 Adjusting the idle speed

- 1 - Back off the nut (89) and screw out the adjuster screw (90) by a few turns
- 2 - Start the engine and, using the hand throttle, bring the revs up to about 750 rpm.
- 3 - Screw in the adjuster screw (90) until you feel it make contact with the internal lever.
- 4 - Return the hand throttle to idle speed position, slowly unscrew the adjuster screw (90) while measuring the engine speed using a precision tachometer; stop when the revs match the rpm indicated in the table. (See: «8.4.1 ADJUSTMENT OF THE FUEL FLOW RATE»).
- 5 - Hold the screw (90) in position and tighten the nut (89).



#### 8.4.6 Sealing the governor

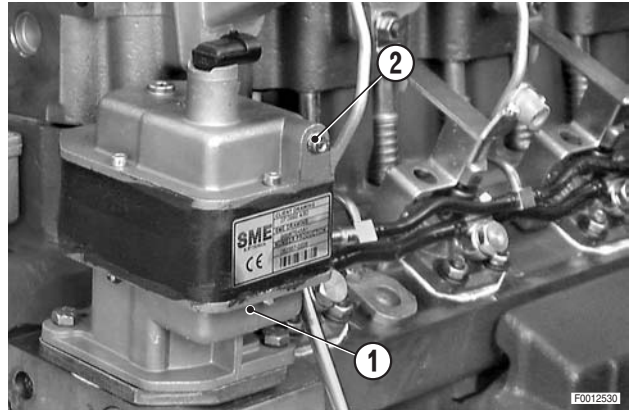
- 1 - After having checked that the governor operates correctly and checked that all the safety caps and adjuster screw lock nuts are properly tightened, apply the tamper-proof seal "C", connecting all the components equipped with holes for this specific purpose and attach a lead seal. Apply a drop of light-coloured paint "D" to the adjuster screw lock nuts.



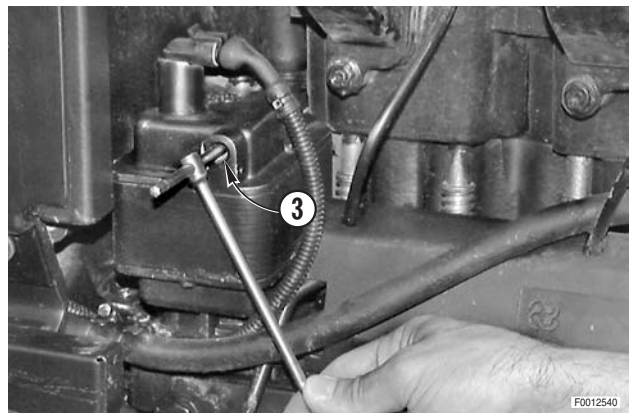


## 9. ADJUSTMENT OF THE ELECTRONIC ACTUATOR

- ★ As with the mechanical governor, adjustments should be made in conditions of safety and with no load on the engine.



- 1 - After renewal of the electronic actuator (1), remove the plug (2) to gain access to the adjuster screw (3).
- 2 - Start the engine and allow it to reach normal operating temperature.
- 3 - Set the engine speed to  $2100 \pm 10$  rpm using the hand throttle.



- 4 - Slowly screw out the adjuster screw (3) until you first detect a slight fall in the engine speed.

- ★ This operation reduces the fuel flow rate; wait a few seconds for the flow rate to stabilise.


- 5 - Screw out the adjuster screw (3) a further few degrees and again wait for the fuel flow to stabilise.

- 6 - Repeat the above procedure a number of times, screwing the adjuster screw out by a few degrees each time until the engine stops.

- 7 - With the engine stopped, slowly screw in screw (3) by the number of turns indicated in the table 9.1.

- ★ Observe the indications given for the number of turns.

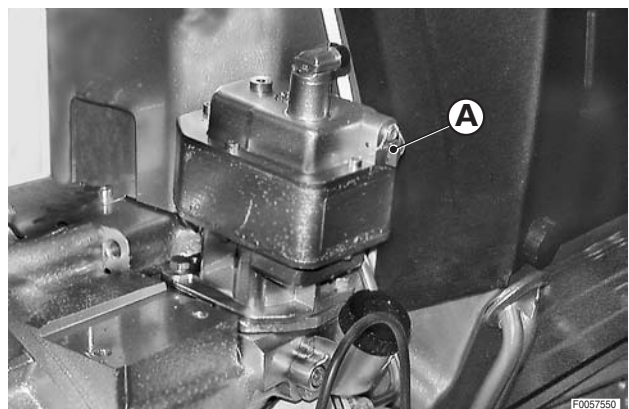
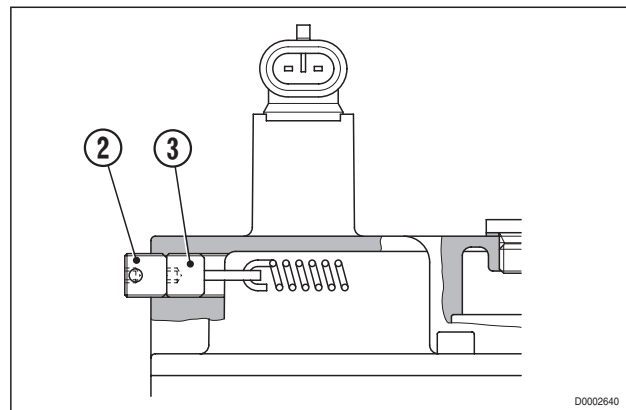
- 8 - Apply a small quantity of low-strength threadlocker to the plug (2) and screw it into the bore in the actuator until rests against the adjuster screw (3).

 Plug: Loctite 222.

- ★ Use only weak threadlocker for precision fixings.

- ★ Do not force the cap (2) on the screw (3).

- 9 - Apply the tamper-proof seal "A".



## 9.1 CALIBRATION OF ELECTRONIC ACTUATORS

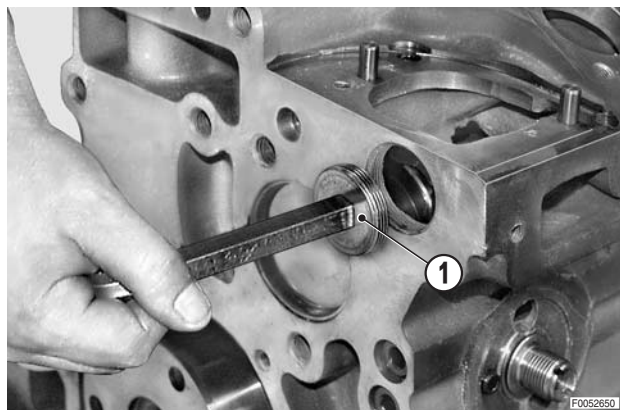
Engine type	Rated power kW (hp)	Engine speed			Fuel control screw
		Minimum rpm'±20	Maximum (without load) rpm(±)	Speed at max. power rpm±5	n° of screw turns at 2100 rpm±10



**THE VALUES FOR THIS PAGE SHALL BE SUPPLIED  
WITH THE NEXT UPDATES**

## 10. REMOVAL OF THE INJECTION PUMP CONTROL ROD

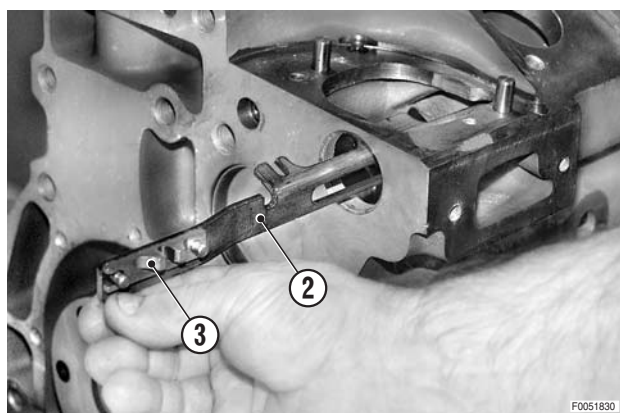
- 1 - Loosen and remove the retaining plug (1).
  - ★ Clean the threads of sealant.



- 2 - Extract the rod (2).

### Electronic actuator versions

- 3 - Recover the control rod linkage plate (3).
  - ★ Take care not to drop the plate (3).

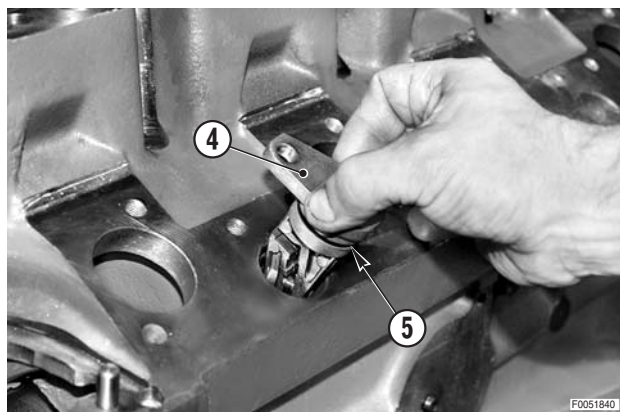


**NOTE.** The rod counter spring is installed at the other end of the engine.  
For its removal, see «DISASSEMBLY OF THE TIMING SYSTEM».

- 4 - Remove the retaining screws and remove the control rod guide assemblies (4).

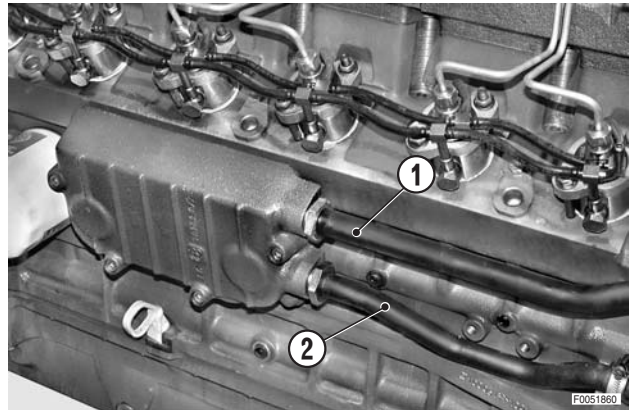
### 6-cylinder versions

- ★ Note that the central control rod guide assembly (7) does not have a guide wheel.
- ★ Renew the O-rings (5) and remove all traces of the old sealant.

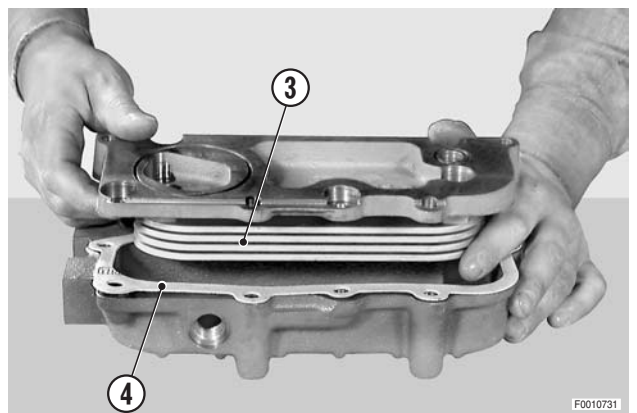


## 11. REMOVAL AND DISASSEMBLY OF THE HEAT EXCHANGER (For 4- and 6-cylinder versions)

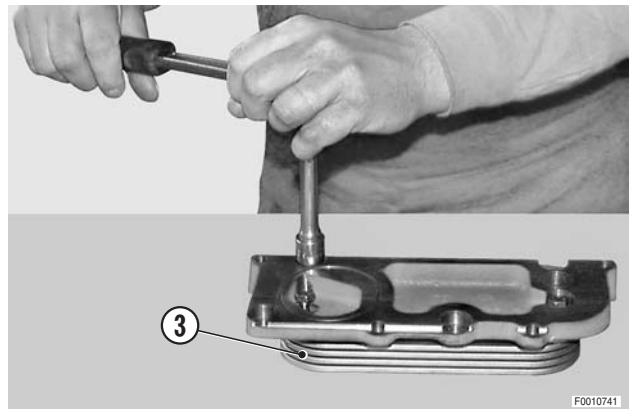
- 1 - Remove pipes (1) and (2) and remove the complete heat exchanger assembly.
  - ★ Check the condition of the O-rings.



- 2 - Dismantle the heat exchanger by removing the oil cooler assembly (3).
  - ★ Renew the gasket (4) at each re-assembly.

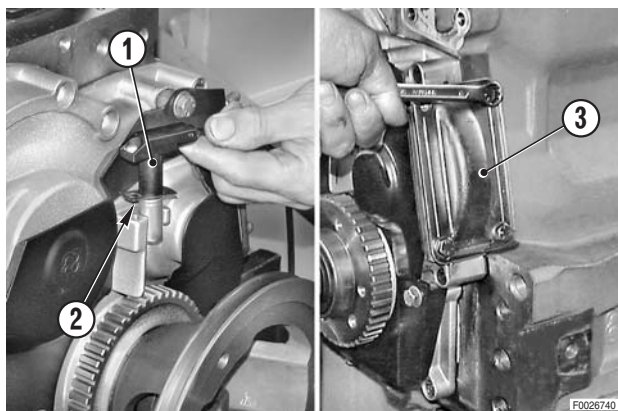


- 3 - Remove the screws and remove the oil cooler (3).
  - ★ Renew the gaskets at each re-assembly.



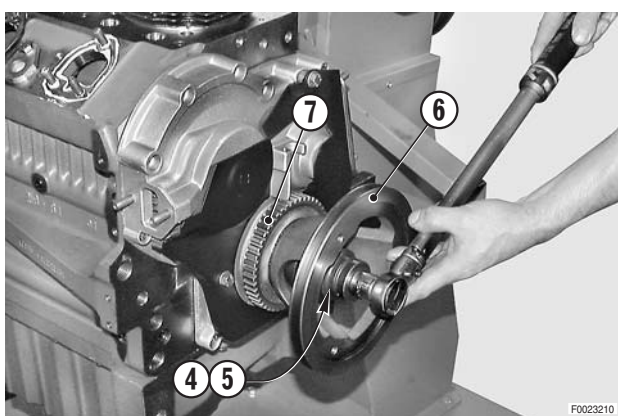
## 12. DISMANTLING THE VALVE TIMING DRIVE

- 1 - **Only if fitted:** remove the screw and remove the engine speed pick-up (1) and the spacer (2).
- 2 - Remove the cover (3).
- ★ This operation is not required if the engine is fitted with a compressor for trailer air braking or a supplementary power take-off.



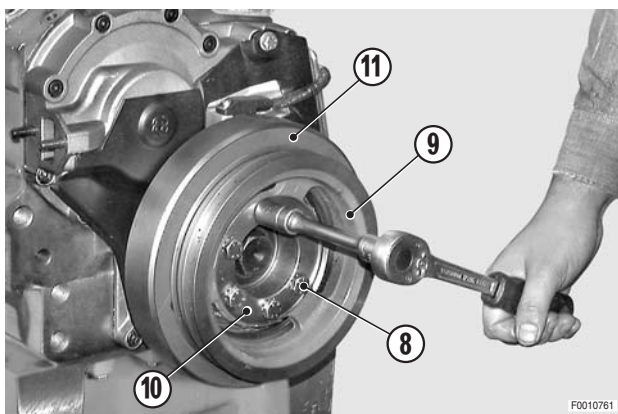
### 3- and 4-cylinder versions

- 3 - Loosen the retaining screw (4) with washer (5) and remove the crankshaft pulley (6) and the pulse wheel (7).



### 6-cylinder version

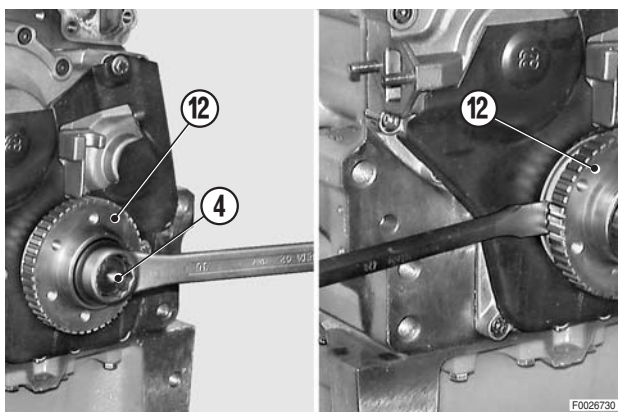
- 3a - Remove the bolts (8) and remove the pulley (9), any shims (10), and the vibration damper (11).



- 3b- Remove the fixing screw (4) of the pulse wheel (12).

- 3c - Remove the pulse wheel.

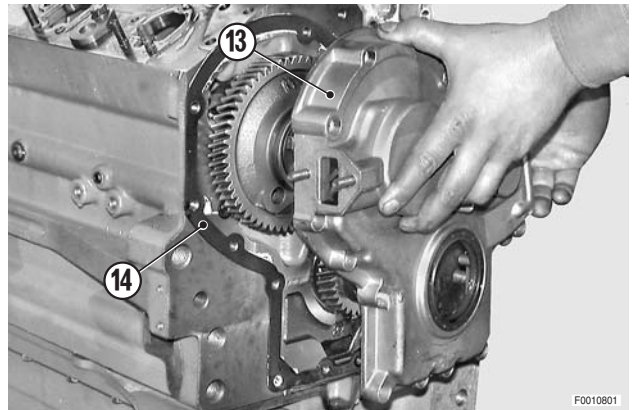
- ★ If necessary, use a lever on opposite sides of the wheel to remove it.



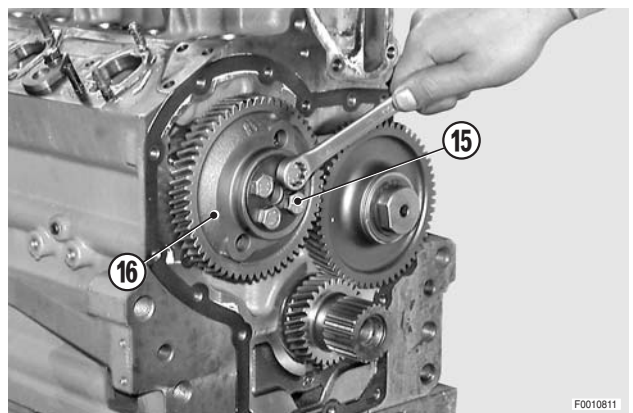


**All versions**

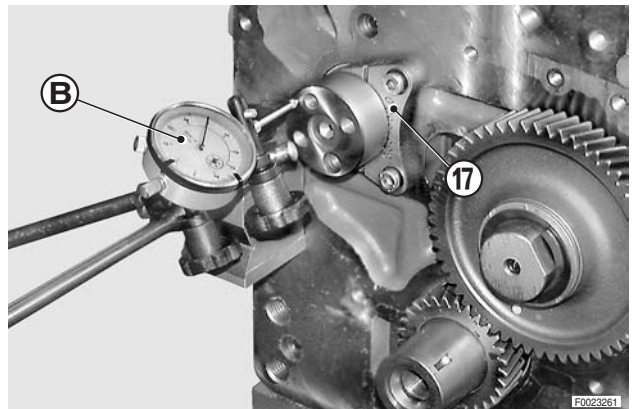
- 4 - Remove the screws and remove the timing cover (13).
- ★ The gasket (14) will remain in position, but must in any case be renewed at each re-assembly.
  - ★ If the crankshaft oil seal is to be renewed see «15. RENEWAL OF THE FRONT CRANKSHAFT OIL SEAL».



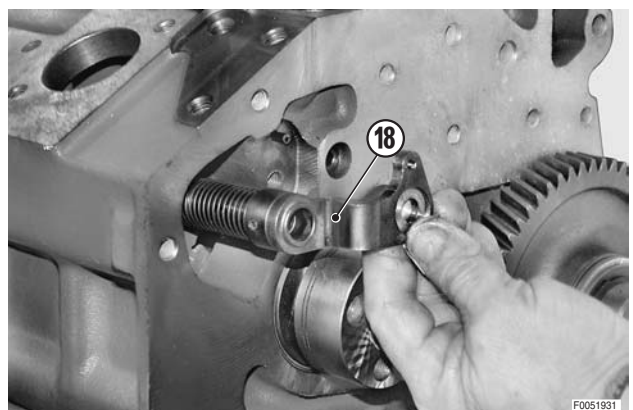
- 5 - Remove the self-locking screws (15) and remove the timing gear (16).
- ★ These screws (15) must be renewed on reassembly.



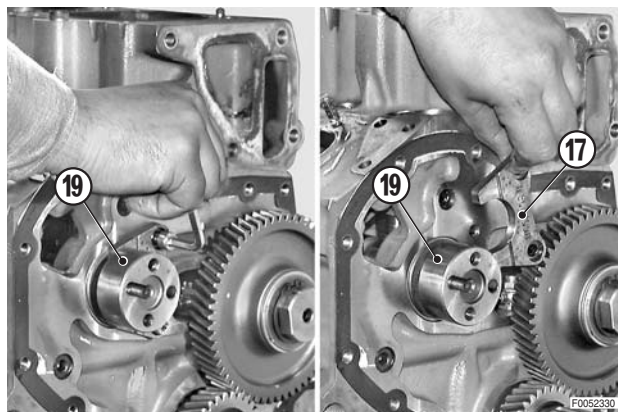
- 6 - Position a dial gauge with magnetic stand so that the contact point rests on the end face of the camshaft and preload the gauge by about 3 mm (0.118 in.). Push the camshaft along its axis in either direction; zero set the dial gauge and then push the camshaft in the opposite direction to measure the endfloat. Check that the measured endfloat is within the prescribed limits (see «TESTS AND TECHNICAL DATA»). If not, replace the camshaft thrust plate (17).



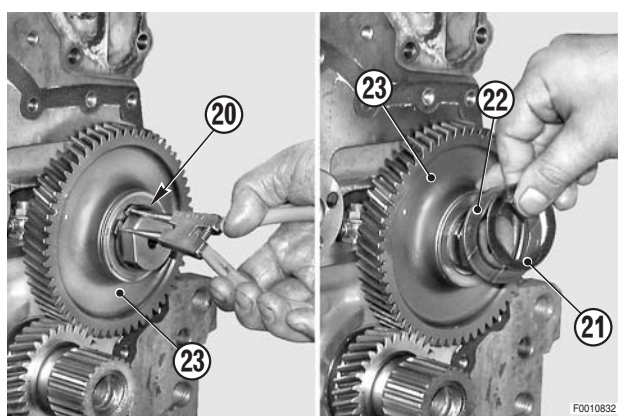
- 7 - Unscrew and remove the counter spring assembly (18) of the injection pumps control rod.



- 8 - Remove the retaining screws (17) and washers and remove the camshaft thrust plate (19).



- 9 - Remove the circlip (20) and shim (21) and remove the bronze thrust washer (22) of the intermediate timing gear (23).

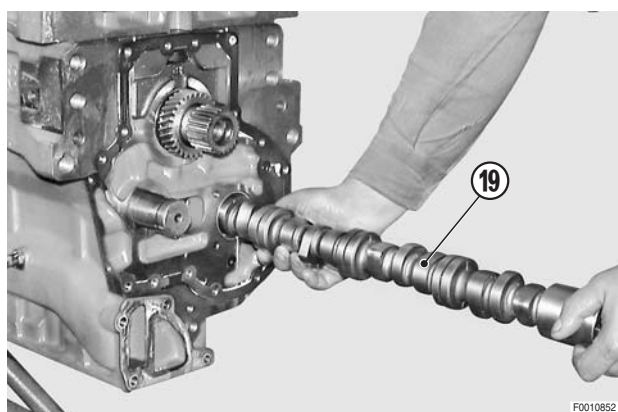


- 10 - Remove the intermediate timing gear (23) and the thrust washer (22).



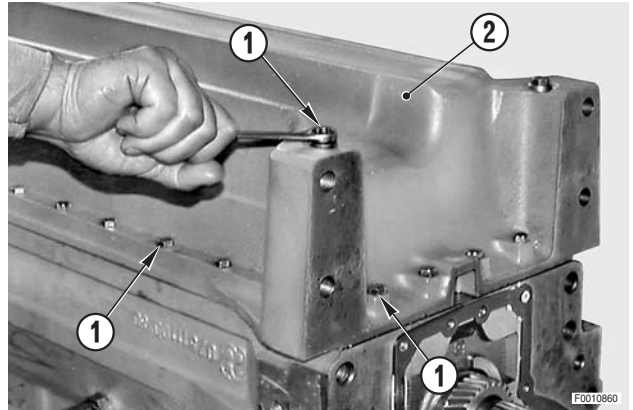
- 11 - Turn the engine upside down and withdraw the camshaft (19).

- ★ Exert a constant pull in the direction of the camshaft axis while rotating the shaft in both directions.
- ★ Take great care not to damage the bearings with the cam lobes.

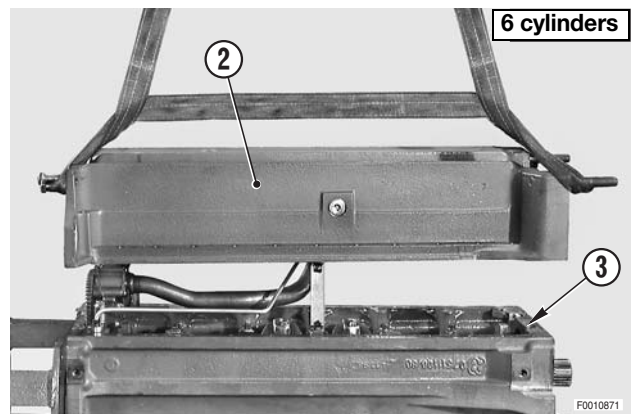
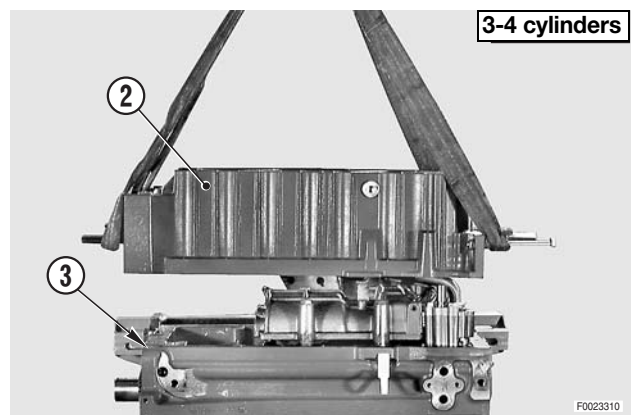


## 13. DISMANTLING THE CRANKSHAFT

- 1 - Loosen and remove the sump pan (2) bolts (1).
  - ★ As there are two types of sump pan, make a note of the positions of the washers and spacers.

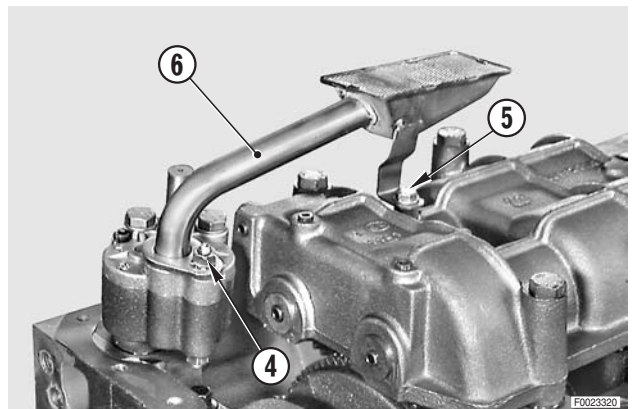


- 2 - Attach the lifting slings of a hoist to the sump pan (2) and lift it clear of the engine block.
  - ★ To break the seal between the sump pan and block, tap the pan gently with a soft mallet.
  - ★ Always renew the gasket (3).



### 3- and 4-cylinders

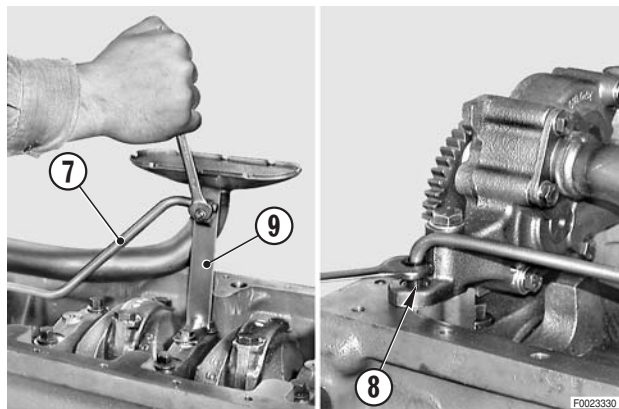
- 3 - Remove the nut (4), the screw (5) and the suction pipe (6).



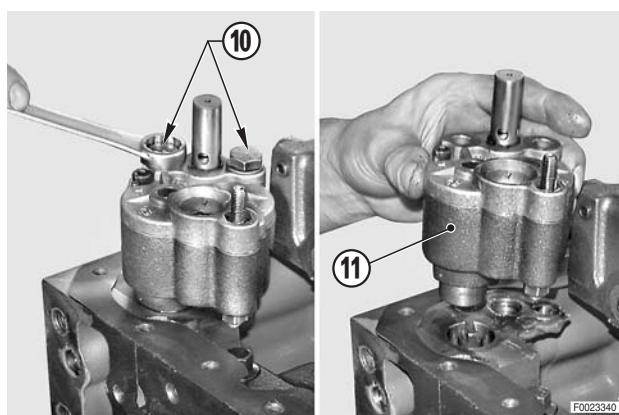


**6-cylinder version**

3a - Remove oil vapour recovery pipe (7) by loosening fitting (8) and the bracket (9) retaining nut.

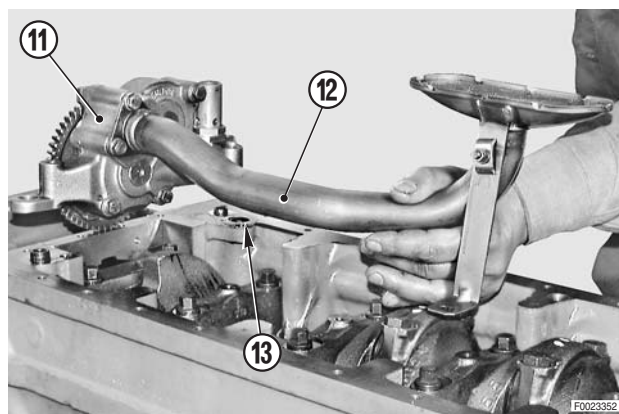
**3- and 4-cylinder versions**

4 - Remove the bolts (10) and the pump (11).

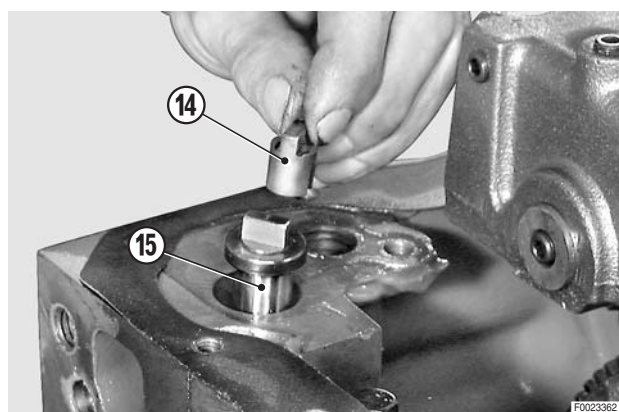
**6-cylinder version**

4a - Remove the bolts and washers and remove the oil pump (11) complete with pick-up pipe (12).

★ Recover shims (13).

**3- and 4-cylinder versions**

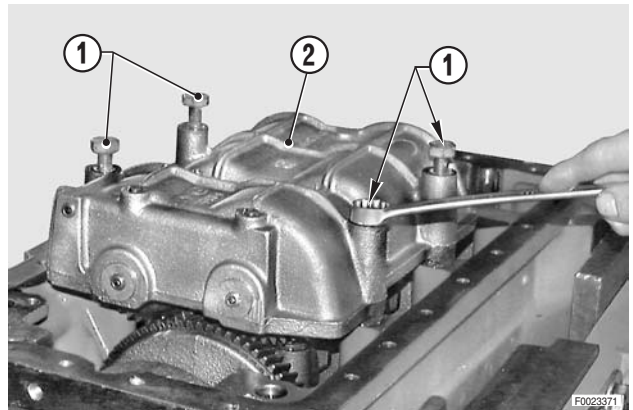
5 - Remove the drive coupling (14) and the shaft (15).



### 13.1 REMOVAL OF THE HARMONIC BALANCER (4-cylinder versions when fitted)

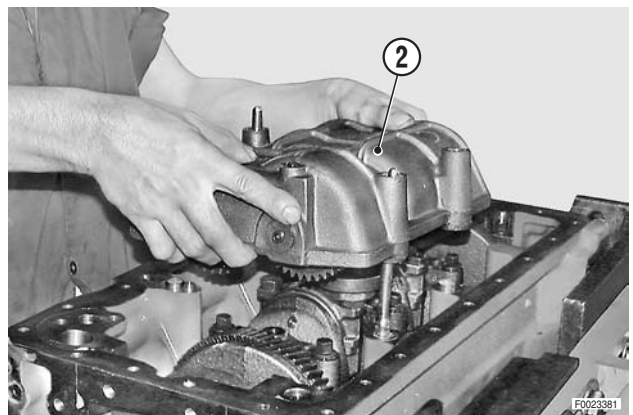
- 1 - Loosen and remove the retaining bolts (1) of the harmonic balancer assembly (2).

★ Loosen the bolts gradually in a cross-wise sequence.



- 2 - Remove the harmonic balancer assembly (2).

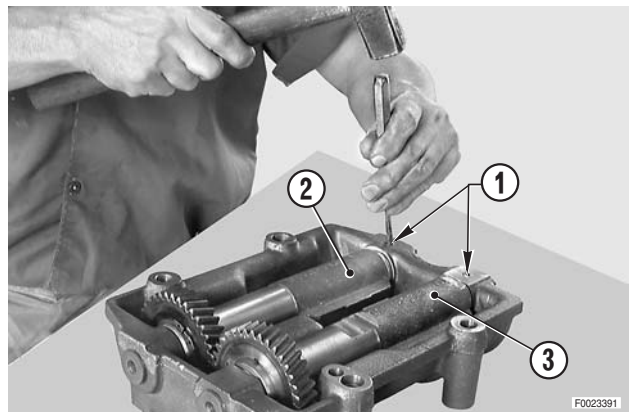
★ Recover any shims.



### 13.2 OVERHAUL OF THE HARMONIC BALANCER (when fitted)

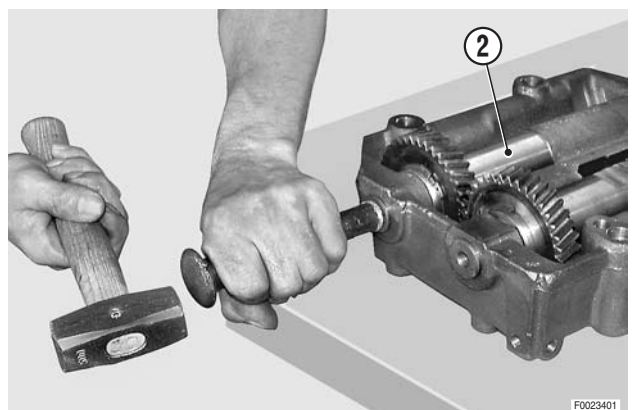
#### 13.2.1 Disassembly

- 1 - Using a pin punch, drive out the spring pins (1) securing the shafts (2) and (3).



- 2 - Using a soft drift (aluminium, copper etc.), drive out the bob weight shafts (2) and (3).

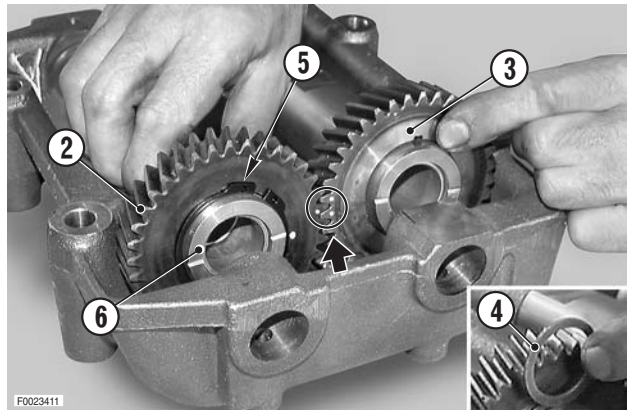
❖ 1





- 3 - Withdraw the shafts (2) and (3) and recover the front and rear shims (4).
- 4 - Remove the circlip (5) from the driven shaft (2) and remove the gear (6).
  - ★ Note that the reference mark on driven gear (2) is positioned between the marked teeth of the driving gear (3).

※ 2



### 13.2.2 Assembly

- Assembly is the reverse of disassembly.

※ 1

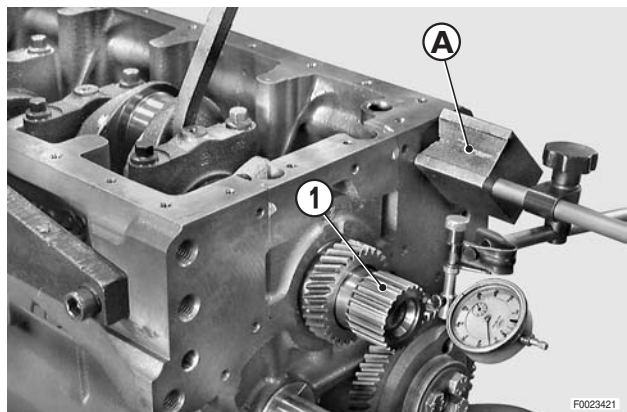
 Shaft: Molikote

※ 2

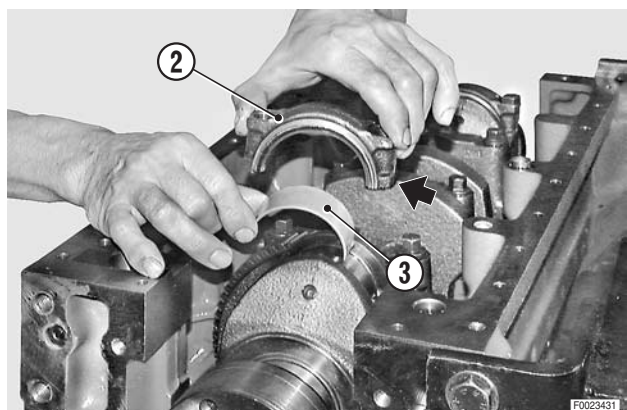
- ★ Check the positioning of the timing marks on the driven and driving gears.

### 13.3 REMOVAL OF THE CRANKSHAFT

- 1 - Position a dial gauge with magnetic stand "A" so that the contact point rests on the end face of the crankshaft (1) and preload the gauge by about 3 mm (0.118 in.).  
Using a lever "B", push the crankshaft along its axis in either direction; zero set the dial gauge and then push the crankshaft in the opposite direction and check that the endfloat is within the prescribed limits.  
If the endfloat exceeds the limit, change the thrust washers for oversize ones (see «TESTS AND TECHNICAL DATA»).

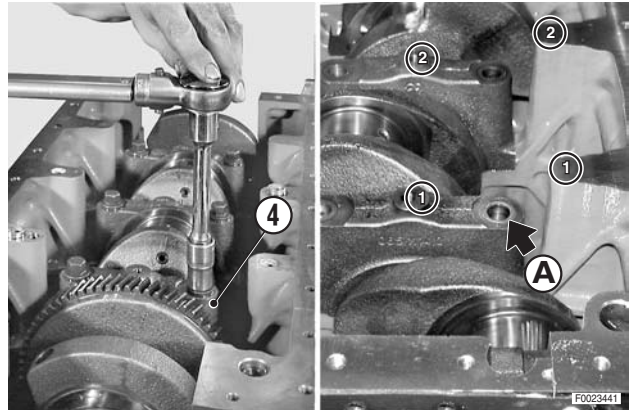


- 2 - Remove the cap bolts and remove the big-end bearing caps (2) complete with the shell bearings (3).
  - ★ Mark the bearing shells with their respective connecting rods for subsequent dimensional checks.
  - ★ Note that the numbers stamped on the big-end caps and their relative connecting rods are positioned towards the injection pump side of the engine.  
Mark the installation positions of the individual connecting rods. If the engine is not to undergo major overhaul, ensure that the connecting rods and caps are refitted in their original positions.



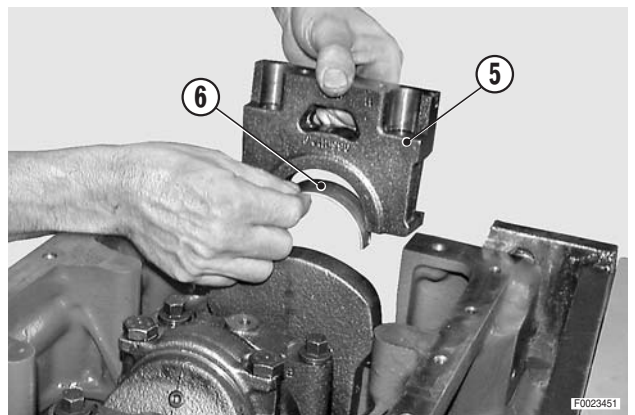
- 3 - Remove the bolts and the central main bearing caps (4) complete with the half shells.

- ★ Mark the half shells with the relative main bearing caps for subsequent dimensional checks.
- ★ Note that the central main bearing caps and their relative crankcase positions are stamped with the same number. The symbol "A" points towards the injection pump side of the engine.



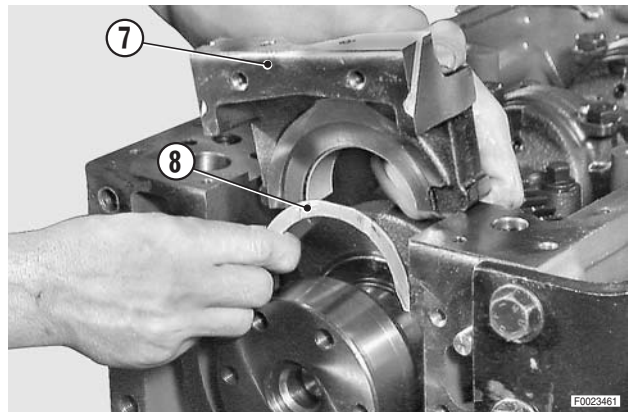
- 4 - Remove the cap bolts and remove the front main bearing cap (5) complete with the half shell (6).

- ★ Mark the front bearing half shell and the corresponding main bearing cap for subsequent dimensional checks.
- ★ Along with the main bearing are also removed the triangular seals that must be renewed at each re-assembly.

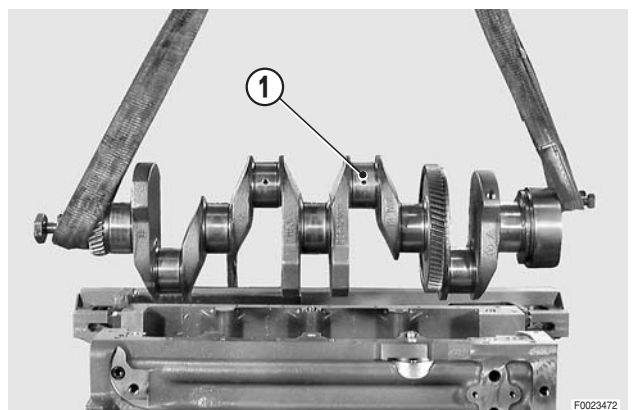


- 5 - Remove the bolts and the rear main bearing cap (7) complete with the half shell and thrust washers (8).

- ★ Mark the half shell and the rear main bearing cap for subsequent dimensional checks
- ★ Note which way round the thrust washers are installed. The oil grooves are oriented towards the crankshaft.
- ★ Along with the main bearing are also removed the triangular seals that must be renewed at each re-assembly.

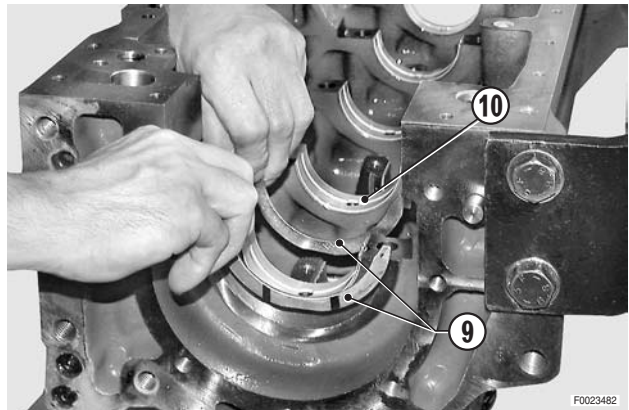


- 6 - Attach the slings of hoist to the crankshaft (1) and lift it clear of the crankcase.



- 7 - Remove the lower halves of the thrust washers (9) and the main shell bearings (10).

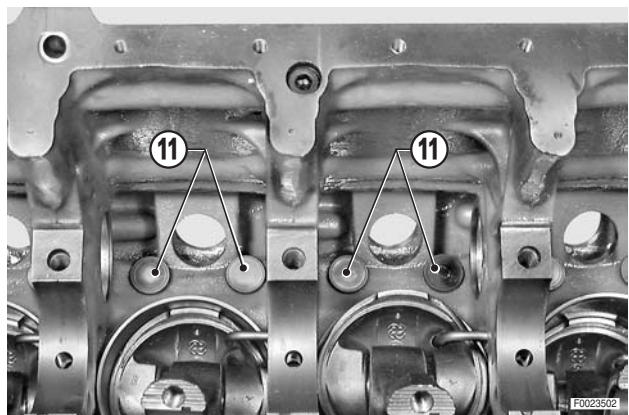
★ Mark the positions of the half shells for subsequent dimensional checks.



- 8 - Remove the cam followers (11) from the engine block.

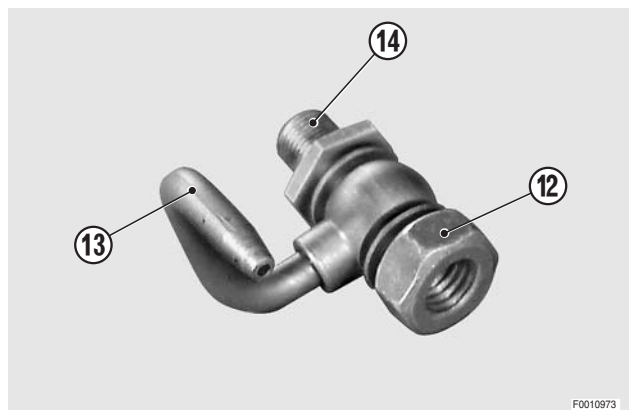
★ Examine the bearing surfaces of the cam followers which are in contact with the cams.

The surfaces should be completely smooth, and the cam followers must be renewed if the bearing surface shows any roughness or indentation.



- 9 - Undo nuts (12) and remove the oil jets (13) with their seals.

★ **Only if necessary:** remove fitting (14).

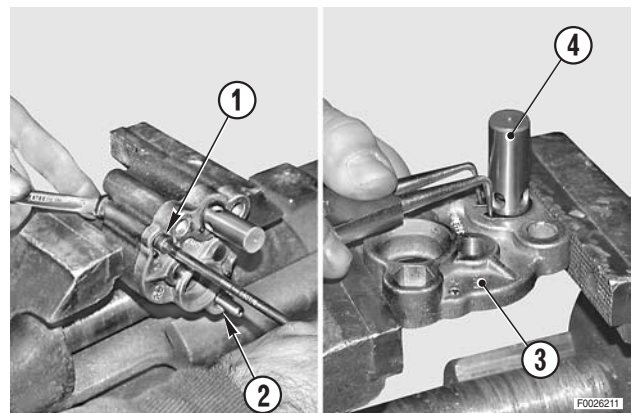


### 13.4 DISMANTLING THE OIL PUMP

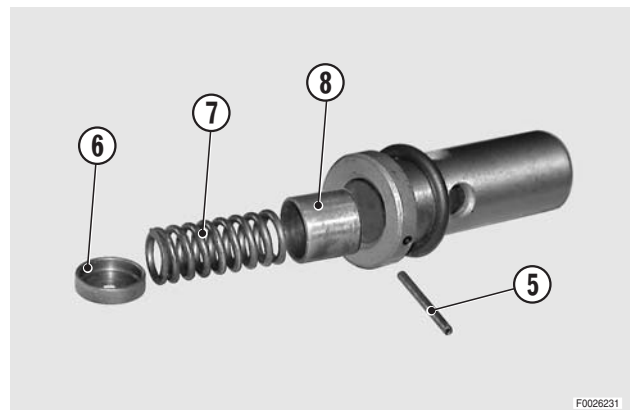
- ★ The only reason for dismantling the oil pump is to carry out a visual inspection of the internal components; if any undue wear is found, the entire pump assembly must be renewed.  
The pressure relief valve should be dismantled if, on testing the pump delivery pressure, the pressure is below the value indicated in the section «TECHNICAL DATA ».

#### 13.4.1 3- and 4-cylinder versions

- 1 - Loosen and remove the bolt (1) and the nut (2).
- 2 - Remove the pump cover (3) and remove the pressure limiting valve (4).




- 3 - Remove the spring pin (5) and dismantle the valve assembly by removing end cap (6), spring (7) and piston (8).
- 3 - Clean carefully and re-assemble the valve, checking that the piston (8) slides freely.  
★ Valve calibration:  $5 \pm 0.5$  bar ( $72.5 \pm 7.25$  psi)



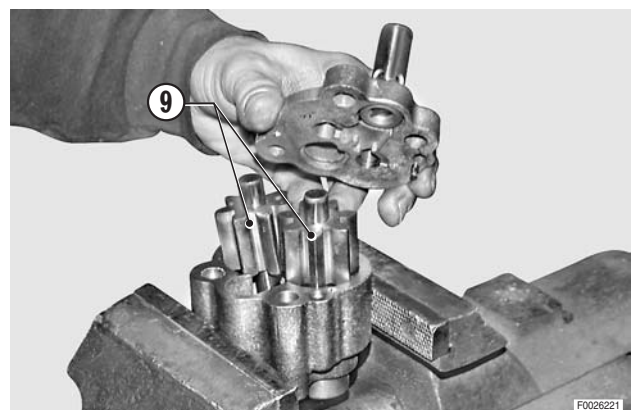
- 5 - Inspect the gears (9) for wear and the pump housing to decide whether to replace the entire assembly.

- ★ On reassembly, oil the gears and the shaft of the drive gear.

 Gears: gear oil

 Bolts: 20.4 Nm (15 lb.ft.)

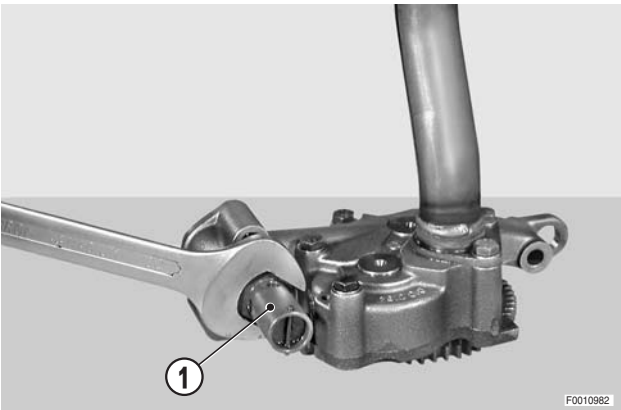
Minimum capacity	700 rpm			2400 rpm		
	ℓ	bar	psi	ℓ	bar	psi
1000.3	11	0.5–1.5	7–22	38	3.5–4.5	51–65
1000.4	16	0.5–1.5	7–22	48	3.5–4.5	51–65






13.4.2 6-cylinder version

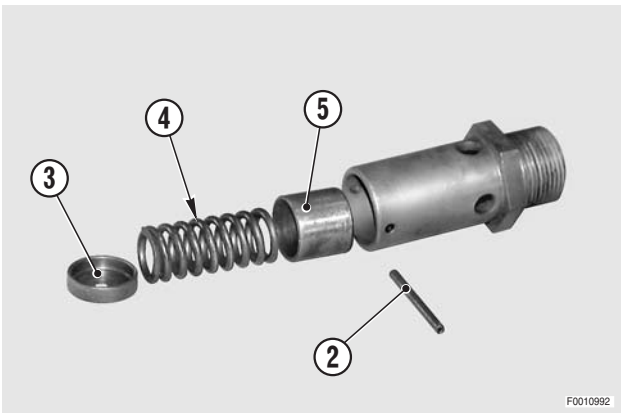
1 - Remove the pressure relief valve (1).



- 2 - Remove the spring pin (2) and dismantle the valve assembly by removing end cap (3), spring (4) and piston (5).
- 3 - Clean carefully and re-assemble the valve, checking that the piston (5) slides freely.


 Valve: 90±5 Nm (66.3±3.7 lb.ft.)


★ Valve calibration: 5±0.5 bar (72.5±7.25 psi)



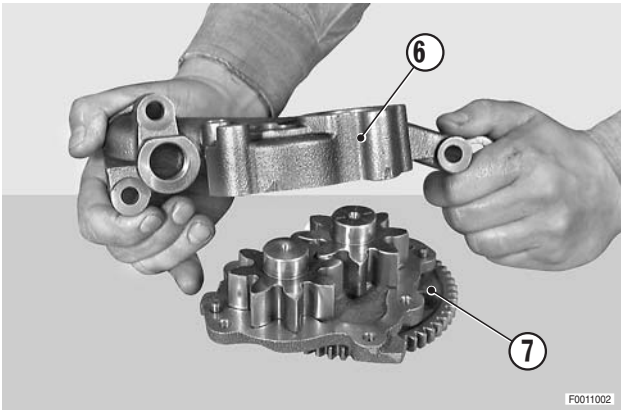
4 - Remove the oil pick-up pipe, screws and remove the pump body (6) in order to inspect the gears (7) and pump body for wear and to decide whether the pump requires renewal.

★ On re-assembly, liberally lubricate the gears and the drive shaft with oil.

 Gears: Gear oil

 Screws: 20.4 Nm (15 lb.ft.)

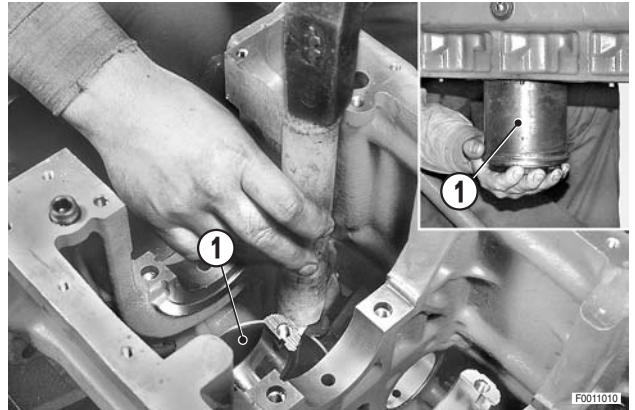
Minimum capacity	700 rpm			2400 rpm		
	ℓ	bar	psi	ℓ	bar	psi
1000.6	39	0.5–1.5	7–22	113	3.5–4.5	51–65



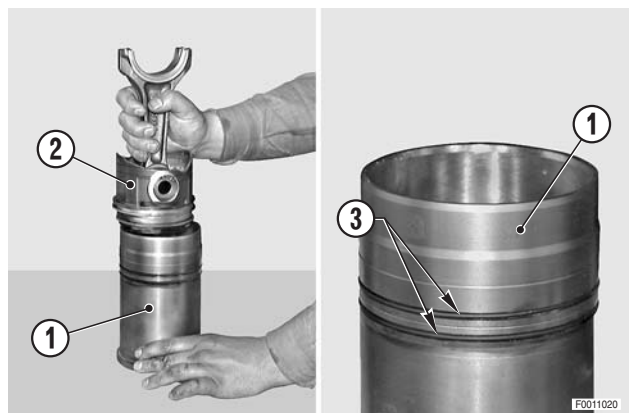


## 14. REMOVAL OF THE PISTONS AND CYLINDER LINERS

- 1 - Use a mallet and a plastic drift to loosen and withdraw the cylinder liners (1) along with the pistons and connecting rods.

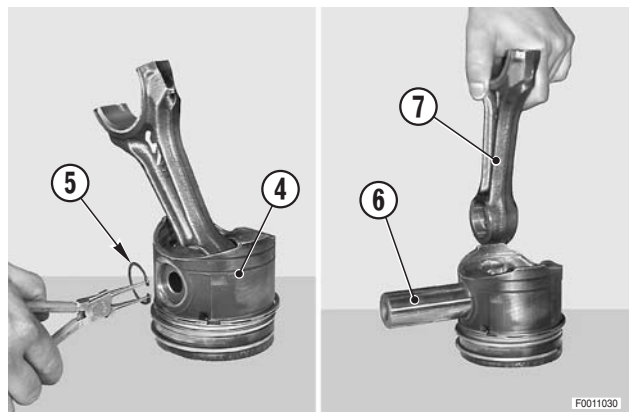


- 2 - Withdraw the piston-connecting rod assembly (2) from the bottom end of the liner (1).
- 3 - Remove the O-ring seals (3) from the cylinder liner (1).
  - ★ The O-rings must be renewed at each re-assembly.



### 14.1 SEPARATING THE PISTON-CONNECTING ROD ASSEMBLY

- 1 - Remove the circlip (5) from the piston (4).
- 2 - Withdraw the gudgeon pin (6) and remove the connecting rod (7).
  - ★ Note that the arrow stamped on the piston crown points in the opposite direction to the number on the connecting rod.



- 3 - Using piston ring pliers, remove the top and second rings (8) and (9) from the piston (4).
  - ★ Note that the word TOP is stamped on the uppermost face of the piston rings.



4 - Remove the oil scraper ring (10).



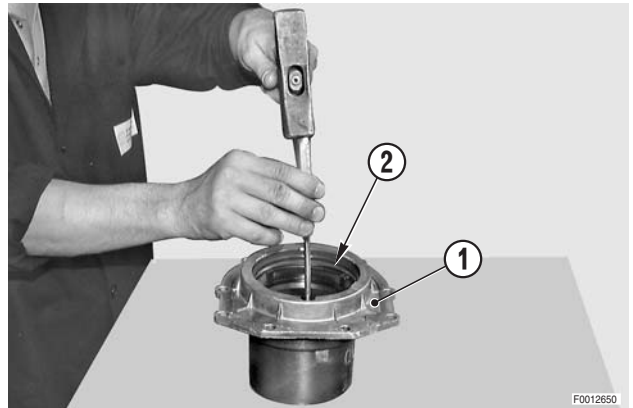
5 - Remove the spring expander (11) of the oil scraper ring (10).



## 15. RENEWAL OF THE REAR CRANKSHAFT OIL SEAL

- 1 - Using a punch, remove the oil seal (2) from the cover (1).

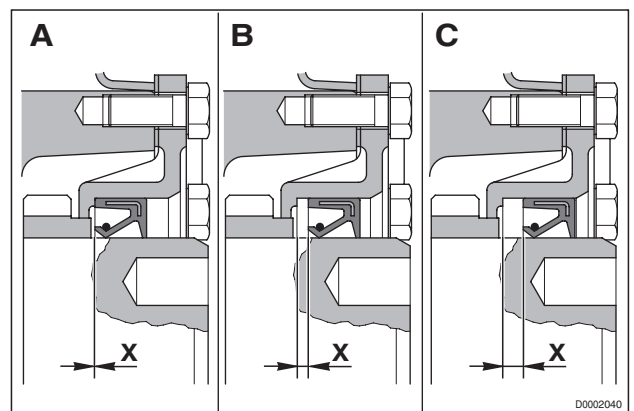
★ Make a note of which way round the seal is installed and its position.



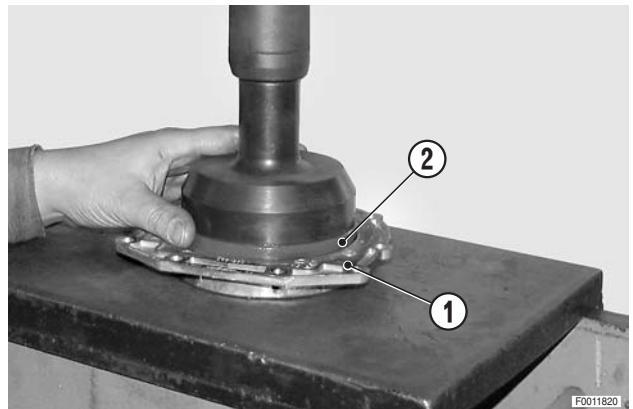
**!** On first assembly, the oil seal (2) is fully inserted in its seating in the carrier.

At each subsequent renewal, the oil seal (2) must be moved a distance of 2.5 mm (0.098 in.) towards the outside of the engine.

ORIGINAL	1st OVERHAUL	2nd OVERHAUL
A	B	C
X= 0 mm (0 in.)	X= 2.5 mm (0.098 in.)	X= 5 mm (0.197 in.)



- 2 - Using a press and a suitable drift, install the new oil seal (2) in the carrier (1) in the correct position as per the indications above.

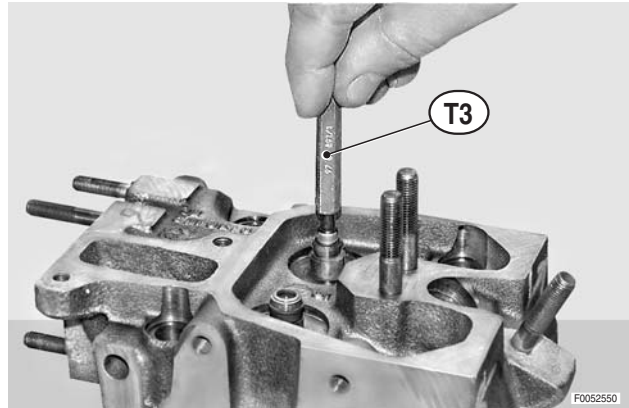


## 16. TESTS - TECHNICAL DATA AND DIMENSIONS

### 16.1 CYLINDER HEADS - VALVES - ROCKER ASSEMBLIES

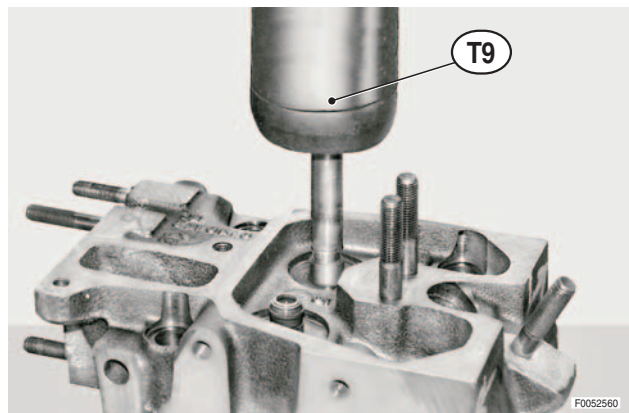
#### 16.1.1 Inspection and renewal of valve guides

- 1 - Examine the valve guides for signs of scuffing or damage.  
Check the inside diameter using a plug gauge T3 (code 5.9030.650.0); if the NP end of the plug gauges enters the guides, they must be renewed.




#### 16.1.2 Renewal of the valve guides

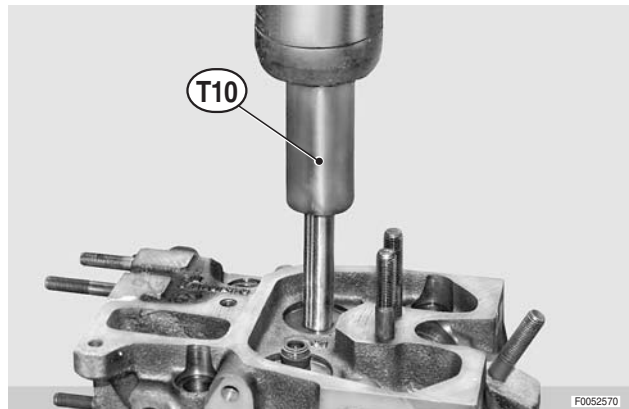
- 1 - Position the cylinder head on a perforated plate under a press; using drift T9 (code 5.9030.850.0) withdraw the valve guides.



- 2 - Carefully clean the valve guide seatings, lubricate the external surfaces of the guides and insert them using tool **T10** (code 5.9030.851.0).

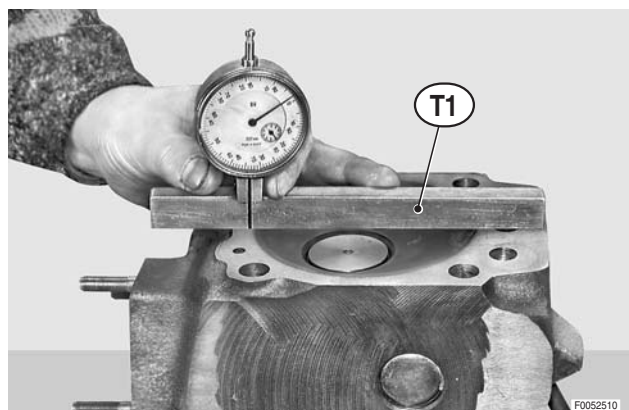
 Valve guides: engine oil

- ★ The correct insertion depth is determined by the full stroke of the insertion tool. (See «TECHNICAL DATA AND DIMENSIONS»)



#### 16.1.3 Inspecting the valve seats

- 1 - Using tool **T1** (code 5.9030.433.0) and a dial gauge, check the valve stand-in relative to the cylinder head surface.
- 2 - If the stand-in of even a single valve is not within the tolerance limits indicated in «TECHNICAL DATA AND DIMENSIONS», all the valve seats will have to be renewed by a specialised engineering shop.



- 3 - Inspect the valve seats and valve faces for signs of pitting or deformation.
- 4 - If the defects are such that they cannot be removed simply by grinding, new valve seats will have to be installed by a specialised machine shop.
  - ★ New valve seats are supplied pre-finished; no further grinding is required after fitting. **Before fitting, the valve seats must be cooled in liquid nitrogen.**
  - ★ For valve-stand-in, seat and face angles see «TECHNICAL DATA AND DIMENSIONS»

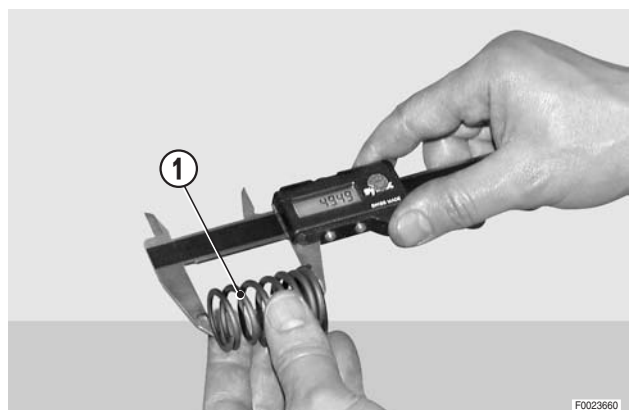
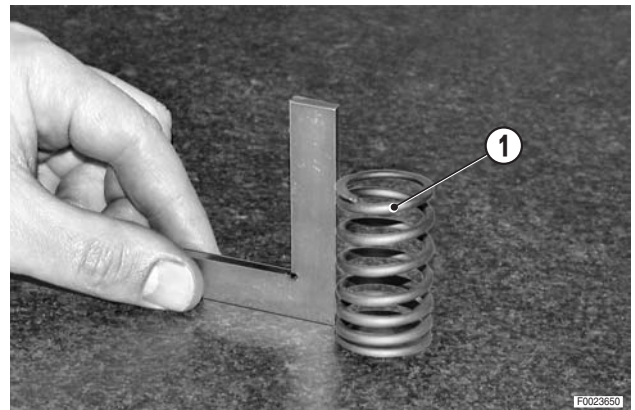
#### 16.1.4 Inspecting the valves

- 1 - Measure the diameter of the valve stem using a micrometer.
  - ★ Measure diameter of the stem at various points along its length and at 90° intervals.
  - ★ If the stem diameter is not within the specified tolerance limits, the valves must be renewed. For tolerance limits, see «TECHNICAL DATA AND DIMENSIONS».



#### 16.1.5 Inspecting the valve springs

- 1 - Stand each valve spring (1) on a flat surface and check it for squareness.
  - ★ If the spring is not square, it must be renewed.
- 2 - Check the length of each valve spring (1).
- 3 - If either of these two parameters is found to be outside the tolerance limits specified in «TECHNICAL DATA AND DIMENSIONS», the springs must be renewed.
  - ★ Springs with signs of corrosion on the coils must also be renewed.

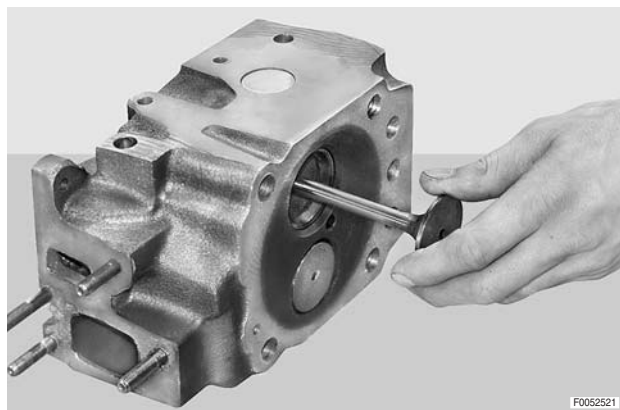




### 16.1.6 Testing the valve seals

- 1 - After cleaning the cylinder head thoroughly, lubricate the valve stems and fit the valves, springs and retainers.
- 2 - Check the valve seal by pouring a few drops of solvent into the inlet and exhaust ports; reground valves should not leak, while for new valves and seats, a slight leakage is permissible.

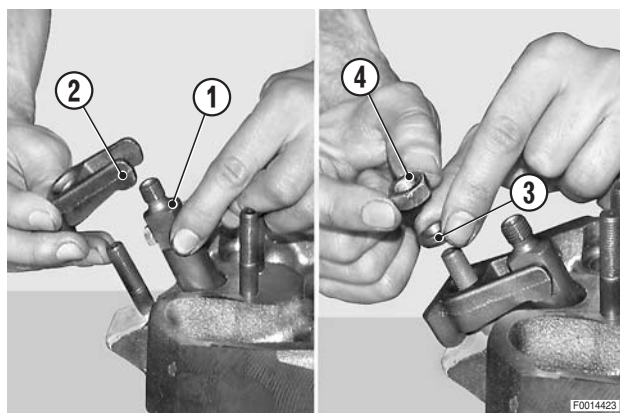
NOTE - The valve seats automatically bed in after a very short time of operation with the engine running



### 16.1.7 Checking injector protrusion

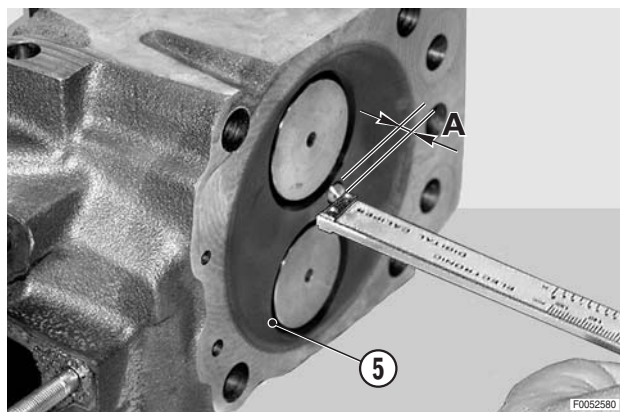
- 1 - Fit the injector (1) in the cylinder head and secure it with bracket (2), tapered washer (3) and nut (4).

 Nut: 39 Nm (28.8 lb.ft.)



- 2 - Use a caliper to measure the protrusion "A" of the injector from the cylinder head surface (5).

★ If the protrusion does not come within the values indicated in the «TECHNICAL DATA AND DIMENSIONS», it will be necessary to replace the copper bush by the procedure given in the following paragraph.



### 16.1.8 Renewal of the copper bushes

- ★ These operations should be carried out by a specialised machine shop.

1 - Ream out the old bush mechanically using a system with swarf extraction; remove enough material from the inside diameter so that the bush can be easily deformed and thus withdrawn.

2 - Remove all traces of old sealant and metal particles from the groove "C".

- ★ Take care not to damage the bush seating bore.

3 - Thoroughly degrease the bush seating bore and the new bush.

4 - Apply silicone sealant to groove "C".

 Sealant: DIRKO TRANSPARENT

- ★ Once the sealant has been applied, the new bush must be inserted within 10-15 minutes; if this time period elapses without inserting the bush, the sealant must be removed and fresh silicone applied.

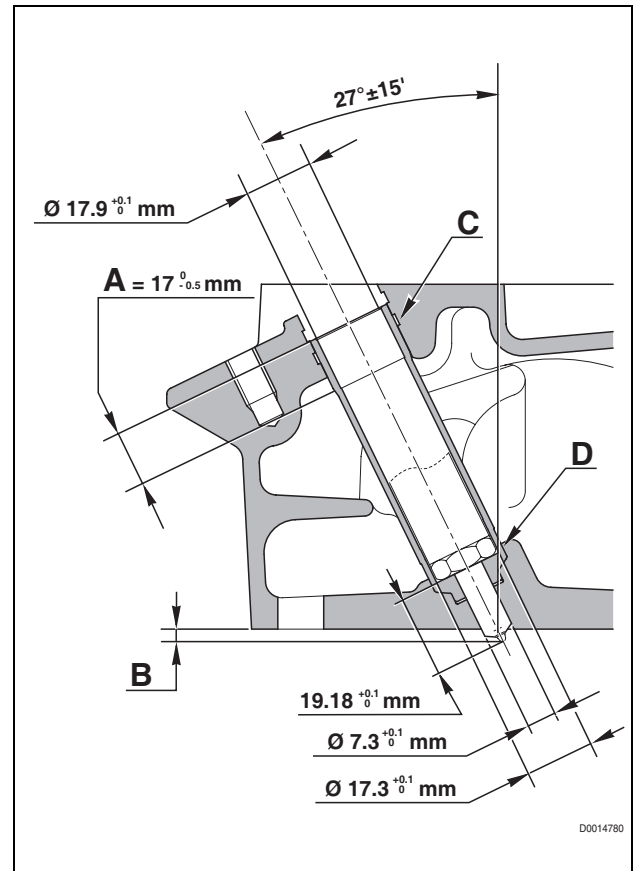
5 - Insert the bush in the bore in the cylinder head and press it fully home against seat "D".

6 - While maintaining the pressure, widen the bush to improve the axial seal to a depth "A" of 31 mm (1.22 in.) from the face.

7 - Calibrate the nozzle seat using a

- ★ Ball calibration tool:  
 $\varnothing 7.3 \pm 1 \text{ mm}$  ( $0.288 \pm 0.0394 \text{ in.}$ )

8 - Check the measure "B" correspond to that indicated in «TECHNICAL DATA AND DIMENSIONS».



### 16.1.9 Inspecting the rocker arms and pivot posts

1 - Measure the inside diameters of the rocker bushes and the diameters of the pivot posts.

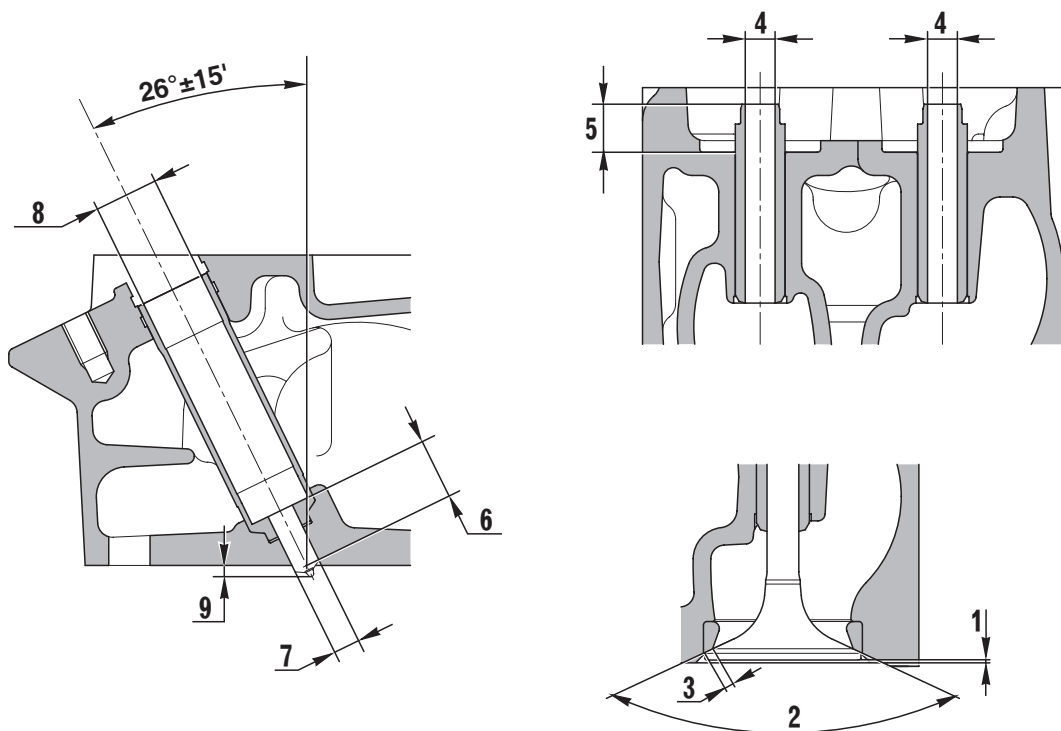
Use a dial bore gauge and a micrometer.

If the wear exceeds the tolerance limits indicated in «TECHNICAL DATA AND DIMENSIONS», renew the rocker bushes and the pivot posts.

- ★ When renewing rocker bushes, take great care that oil holes and grooves are correctly oriented (see «TECHNICAL DATA AND DIMENSIONS»).

# TECHNICAL DATA AND DIMENSIONS

## CYLINDER HEADS - VALVE GUIDES - VALVE SEATS

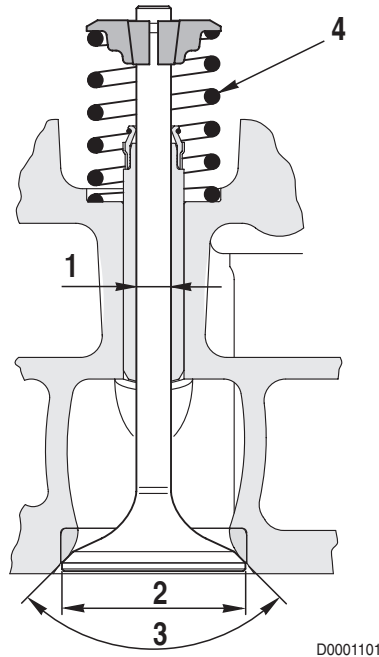


D0014890

Unit of measurement: mm (in.)

Pos.	Dimensions		Normal measurement	Tolerance limit	NOTES
1	Valves stand-in	Inlet	0.7–1.3 (0.028 – 0.051)	1.8 (0.0709)	
		Exhaust	0.9–1.5 (0.035 – 0.060)	2.0 (0.0788)	
2	Valve seat angle	Inlet	120°	–	
		Exhaust	90°	–	
3	Contact band (valve to seat)	Inlet	2.10 (0.083)		
		Exhaust	2.21 (0.087)		
4	Inside diameter of valve guide		9.025 (0.364) 9.040 (0.356)		Renew when the clearance between the guide and the valve exceeds 0.1 mm (0.004 in.).
5	Protrusion of valve guide above spring seat	Inlet	14.3 – 14.7 (0.563 – 0.579)		
		Exhaust			
6	Length of injector nozzle holder		19.28 – 19.18 (0.760 – 0.752)		
7	Injector nozzle holder bore		7.3 – 7.4 (0.288 – 0.292)	–	
8	Copper bushing bore		17.9 – 18 (0.705 – 0.709)	–	
9	Injector protrusion		2.383 – 3.095 (0.094 – 0.122)	–	

## VALVES - VALVE SPRINGS



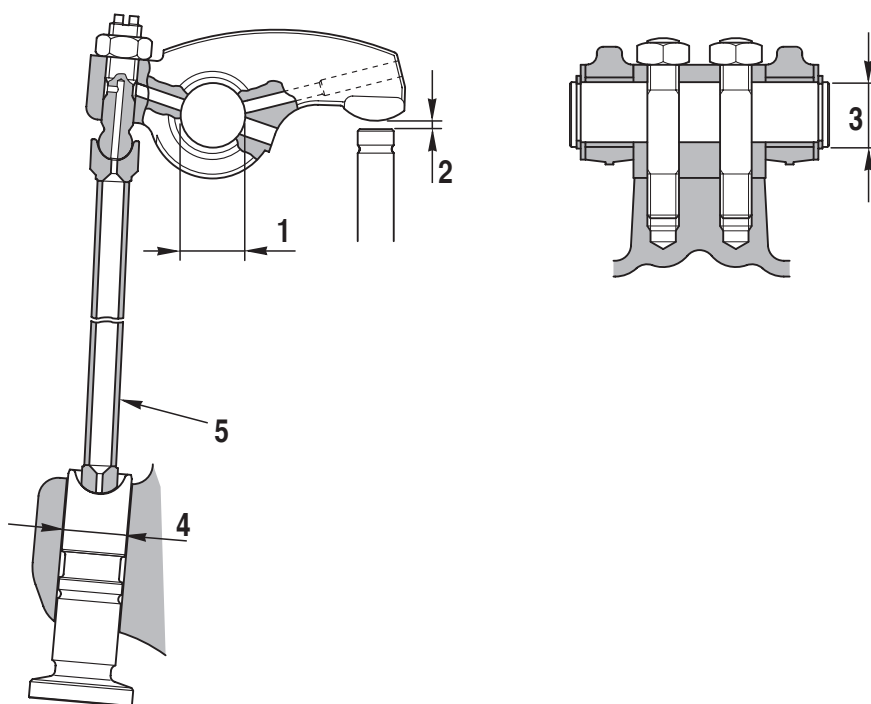
D0001101

**!** The end of the spring where the spirals are closer together should be in contact with the head.

Unit of measurement: mm (in.)

Pos.	Dimensions		Normal measurement	Tolerance limit	NOTES
1	Valve stem diameter	Inlet	8.987 (0.3540) 8.972 (0.3535)		Renew when the clearance between the guide and the valve exceeds 0.1 mm (0.004 in.)
		Exhaust	8.987 (0.3540) 8.980 (0.3538)		
2	Valve head diameter	Inlet	44.1 – 43.9 (1.737 – 1.729)		
		Exhaust	39.5 – 39.3 (1.556 – 1.548)		
3	Valve face angle	Inlet	121° <sub>0</sub> ′ <sup>15</sup> ′		
		Exhaust	90° ± 15′		
4	Valve spring free length	Inlet	53.6 (2.112)		
		Exhaust	—		
	Angle	Inlet	—	—	No deviation from perpendicular permitted
		Exhaust	—	—	

## ROCKER ARMS - ROCKER PIVOT POSTS - TAPPETS



D0003050

Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Inside diameter of rocker-arm bush	19.015 (0.749) 19.025 (0.746)		Renew when the clearance between the rocker-arm bush and pivot post exceeds 0.08 mm (0.0031 in.).
2	Inlet valve clearances	0.15 (0.006) 0.25 (0.001)	—	
	Exhaust valve clearance	0.15 (0.006) 0.25 (0.001)	—	
3	Diameter of rocker arm pivot posts	19–18.987 (0.749–0.748)		
4	Outside diameter of cam follower stem	15.984 (0.630) 15.966 (0.629)	—	
5	Push-rod flexure	—	Max. 0.3 (Max. 0.012)	



## 16.2 INJECTORS - INJECTION PUMPS

### 16.2.1 Testing the injectors

- ★ The injectors are to be tested for spray formation and opening pressure.
- 1 - Unscrew the nozzle holder (1), remove the complete nozzle assembly (2) and the direction control plate (3) and empty the injector any remaining fuel.
    - ★ The injector must be emptied of all residual fuel before testing.
    - ★ Renew the copper gasket.
  - 2 - Re-assemble the plug (1) and connect it to the injector test unit.
 

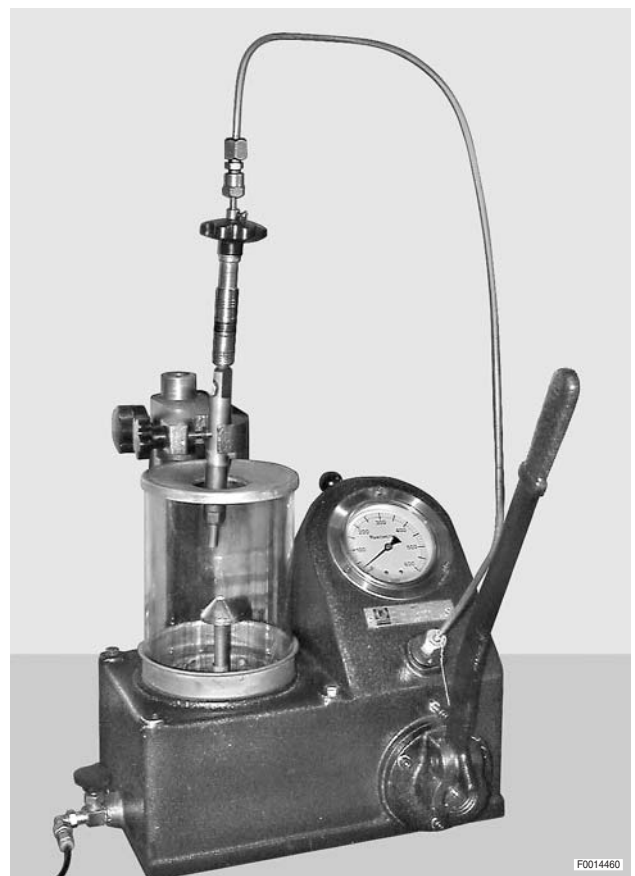
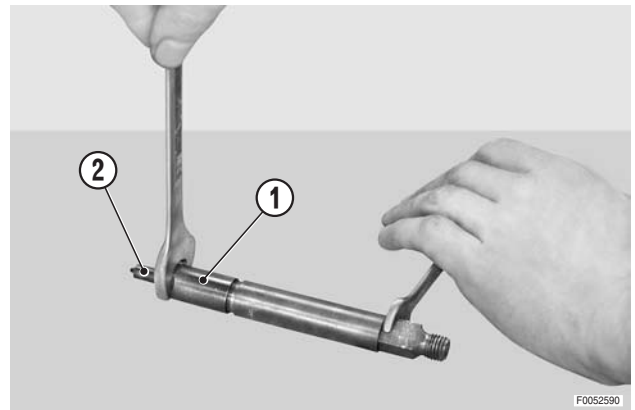
Operate the hand lever to pump air out of the circuit and fill the injector with fuel.

Operate the pump slowly while observing the pressure gauge to check the opening pressure.

Repeat the test a number of times to check that the opening pressure remains constant.

    - ★ This method is also used to test the uniformity of the spray pattern; the number of fuel jets should correspond to the number of holes in the nozzle and these jets should be both finely atomised and uniform.

If the opening pressure does not correspond to that indicated in «TECHNICAL DATA AND DIMENSIONS», the injector will have to be calibrated by a specialised repair shop.
  - 3 - Also test the seal between the nozzle seat and the needle valve. To do this, operate the pump to build up the pressure that is approx. 10% lower than the opening pressure.
- Maintain the pressure and check that no fuel leaks from the nozzle.
- If leakage occurs, the entire injector assembly must be renewed.



Injector type:..... code 2.4719.630.0  
Calibration pressure: .....180±8 bar (2610.5±116 psi)  
Max. injection pressure: ..... 1200 bar (17403 psi)  
Nozzle type: .....Dwg. 2.4729.620.0  
Nozzle holder: type D.17 .....Dwg. 2.4719.590.0 (yellow paint mark)



**TESTING THE INJECTION PUMPS**

Injection pump testing and calibration must be carried out by a specialised service centre equipped with a pump test bench and the necessary test and calibration equipment.

The service centre must be given the technical specifications indicated in this section.

**PUMP CHARACTERISTICS code 2.4619.270.0**

Injection pump	type	BOSCH PFM1A 90S 2504
Pumping element code (BOSCH)		0 414 396 005
Identification plate	colour	Green
Control rod stop position at point X	mm (in.)	9.5 (0.374)
Full stroke	mm (in.)	19 (0.749)
Nominal pre-lift for delivery start	mm (in.)	4.2 (0.165)
Constant pressure reflux valve calibrated to	bar (psi)	70 (1015.2)
BDC Cam Box	mm (in.)	56 (2.206)
Cam lift	mm (in.)	10 (0.394)

**TEST METHOD**

• Cam Box	BOSCH D 412 010 466 - 3 247 5 0133
• Engine injector:	Dis. 1.688.901.031
• Pressure	172 bar (2494 psi)
• High-pressure fuel pipe:	Ø 6x1x267 mm (0.236x0.040x10.512 in.)
• Supply pressure:	0.4 ± 0.05 bar (5.8 ± 0.725 psi)
• Cam:	BOSCH C 412 010 658 - 3 247 5 0133 003

**INJECTION PUMP CALIBRATION**

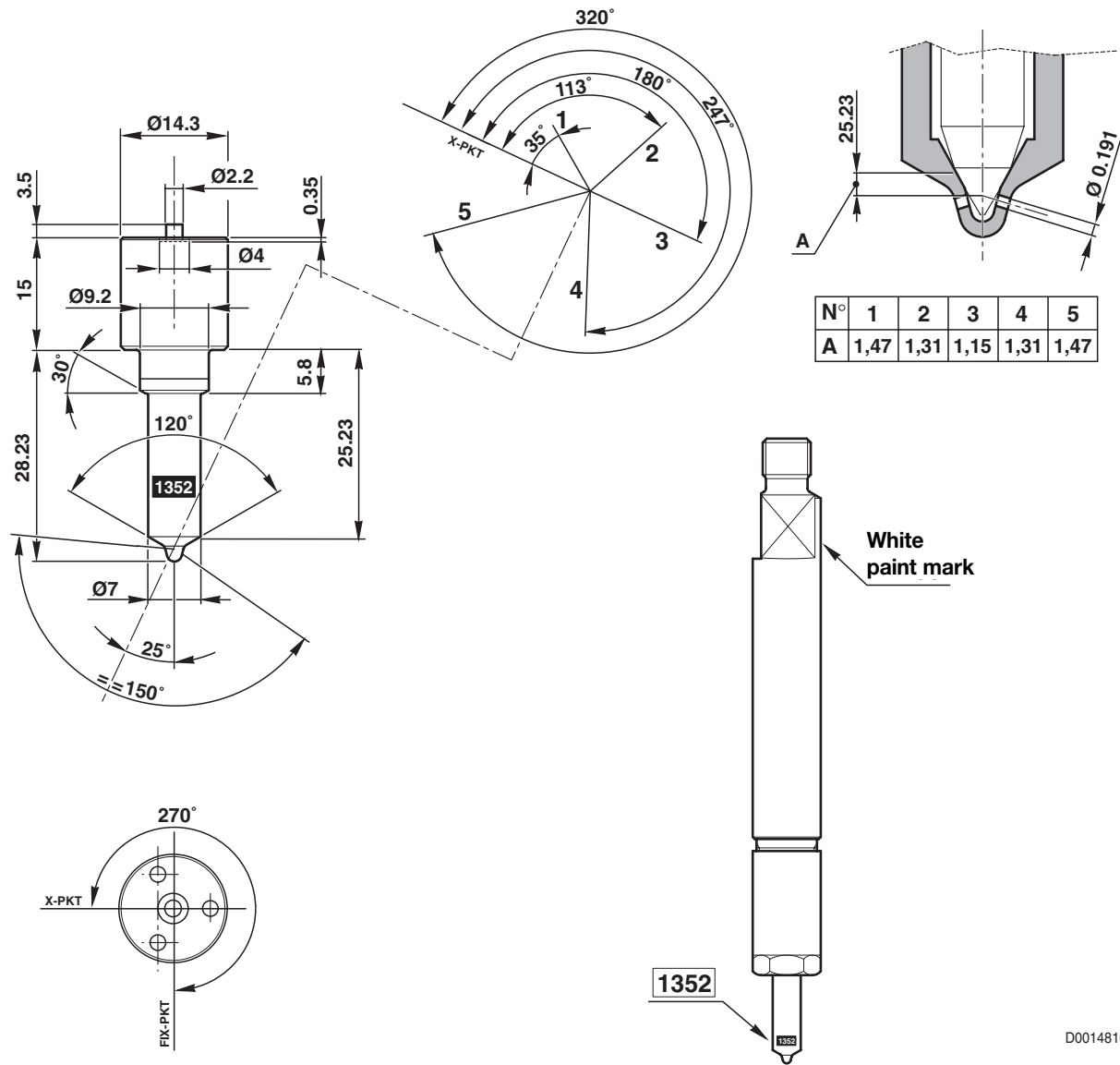
	Rotation speed rpm	Control rack- stroke mm	Delivery (mm <sup>3</sup> /shot)	
			Calibration	Test
Calibration	375	- 1.0 (- 0.0394)	14.0-15.0	9.5-19.5
1st test	700	4.7 (0.185)	107.5-113.5	106.5-114.5
2nd test	1100	4.7 (0.185)	99.0-105.0	98.0-106.0
3rd test	100	9.0 (0.355)	119.5-137.5	118.5-138.5

**CALIBRATION METHOD**

- 1 - Position the pump on the Cambox, with the lever in the STOP position.
- 2 - Set the measuring instrument to zero.
- 3 - Move the control lever from the STOP position to the full stroke position (19 mm).
- 4 - Lock the control lever in position with a BOSCH lock pin.
- 5 - Fix the pump to the plunger assembly.
- 6 - Release the control lever by removing the BOSCH pin and move the plunger assembly to the STOP position (the control lever stroke should return to "zero")
- 7 - Check that stroke distance from the STOP position to the full-stroke position is 19 mm.
- 8 - Check that injection starts at a plunger stroke position of 5.5 – 5.65 mm with a control rod stroke of 2 mm.

INJECTOR TECHNICAL DATA - TURBOCHARGED ENGINES

Injector type:.....code 2.4719.640.0  
Calibration pressure: .....180±8 bar (2610.5±116 psi)  
Max. injection pressure: .....1200 bar (17403 psi)  
Nozzle type: .....Dwg. 2.4729.630.0  
Nozzle holder: type D.17 .....Dwg. 2.4719.590.0 (white paint mark)



D0014810

**TESTING THE INJECTION PUMPS**

Injection pump testing and calibration must be carried out by a specialised service centre equipped with a pump test bench and the necessary test and calibration equipment.

The service centre must be given the technical specifications indicated in this section.

**PUMP CHARACTERISTICS code 2.4619.270.0**

Injection pump	type	BOSCH PFM1A 90S 2504
Pumping element code (BOSCH)		0 414 396 005
Identification plate	colour	Green
Control rod stop position at point X	mm (in.)	9.5 (0.374)
Full stroke	mm (in.)	19 (0.749)
Nominal pre-lift for delivery start	mm (in.)	4.2 (0.165)
Constant pressure reflux valve calibrated to	bar (psi)	70 (1015.2)
BDC Cam Box	mm (in.)	56 (2.206)
Cam lift	mm (in.)	10 (0.394)

**TEST METHOD**

• Cam Box	BOSCH D 412 010 466 - 3 247 5 0133
• Engine injector:	Dis. 1.688.901.031
• Pressure	172 bar (2494 psi)
• High-pressure fuel pipe:	Ø 6x1x267 mm (0.236x0.040x10.512 in.)
• Supply pressure:	0.4±0.05 bar (5.8±0.725 psi)
• Cam:	BOSCH C 412 010 658 - 3 247 5 0133 003

**INJECTION PUMP CALIBRATION**

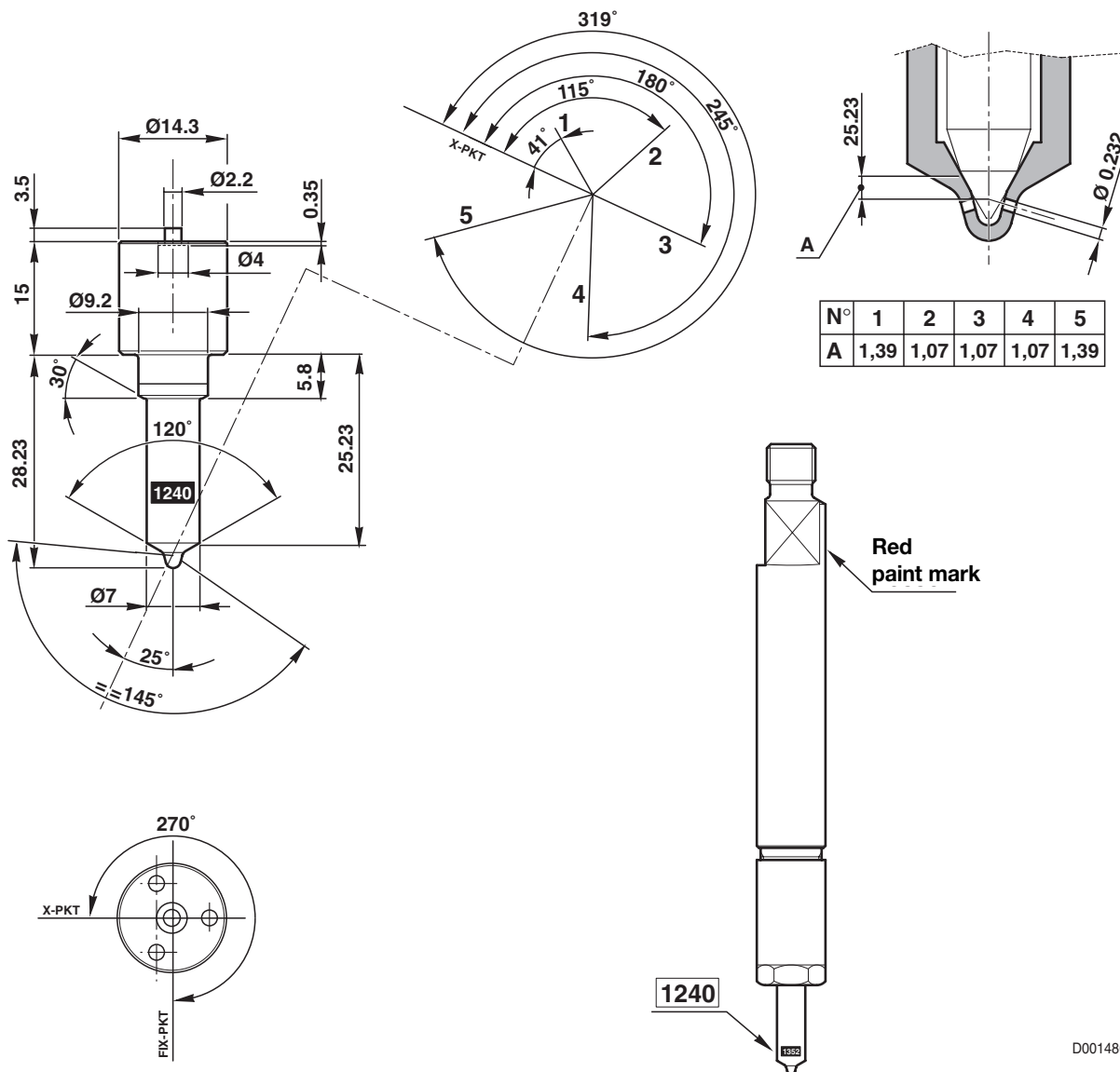
	Rotation speed rpm	Control rackstroke mm	Delivery (mm <sup>3</sup> /shot)	
			Calibration	Test
Calibration	375	- 1.0 (- 0.0394)	14.0-15.0	9.5-19.5
1st test	700	4.7 (0.185)	107.5-113.5	106.5-114.5
2nd test	1100	4.7 (0.185)	99.0-105.0	98.0-106.0
3rd test	100	9.0 (0.355)	119.5-137.5	118.5-138.5

**CALIBRATION METHOD**

- 1 - Position the pump on the Cambox, with the lever in the STOP position.
- 2 - Set the measuring instrument to zero.
- 3 - Move the control lever from the STOP position to the full stroke position (19 mm).
- 4 - Lock the control lever in position with a BOSCH lock pin.
- 5 - Fix the pump to the plunger assembly.
- 6 - Release the control lever by removing the BOSCH pin and move the plunger assembly to the STOP position (the control lever stroke should return to "zero")
- 7 - Check that stroke distance from the STOP position to the full-stroke position is 19 mm.
- 8 - Check that injection starts at a plunger stroke position of 5.5 – 5.65 mm with a control rod stroke of 2 mm.



Injector type:.....code 2.4719.620.0  
Calibration pressure: .....180±8 bar (2610.5±116 psi)  
Max. injection pressure: .....1200 bar (17403 psi)  
Nozzle type: .....Dwg. 2.4729.490.0  
Nozzle holder: type D.17 .....Dwg. 2.4719.590.0 (red paint mark)



**TESTING THE INJECTION PUMPS**

Injection pump testing and calibration must be carried out by a specialised service centre equipped with a pump test bench and the necessary test and calibration equipment.

The service centre must be given the technical specifications indicated in this section.

**PUMP CHARACTERISTICS code 2.4619.190.0**

Injection pump	type	BOSCH PFM1A 90S 2503
Pumping element code (BOSCH)		0 414 396 004
Identification plate	colour	Blue
Control rod stop position at point X	mm (in.)	9.5 (0.374)
Full stroke	mm (in.)	19 (0.749)
Nominal pre-lift for delivery start	mm (in.)	4.2 (0.165)
Constant pressure reflux valve calibrated to	bar (psi)	70 (1015.2)
BDC Cam Box	mm (in.)	56 (2.206)
Cam lift	mm (in.)	10 (0.394)

**TEST METHOD**

• Cam Box	BOSCH D 412 010 466 - 3 247 5 0133
• Engine injector:	Dis. 1.688.901.031
• Pressure	172 bar (2494 psi)
• High-pressure fuel pipe:	Ø 6x1.5x267 mm (0.236x0.059x10.512 in.)
• Supply pressure:	0.4 ± 0.05 bar (5.8 ± 0.725 psi)
• Cam:	BOSCH C 412 010 658 - 3 247 5 0133 003

**INJECTION PUMP CALIBRATION**

	Rotation speed rpm	Control rackstroke mm	Delivery (mm <sup>3</sup> /shot)	
			Calibration	Test
Calibration	375	– 1.0 (– 0.0394)	14.0–15.0	9.5–19.5
1st test	700	4.8 (0.189)	109.0–115.0	108.0–116.0
2nd test	1175	4.8 (0.189)	99.0–105.0	98.0–106.0
3rd test	100	9.0 (0.355)	119.5–137.5	118.5–138.5

**CALIBRATION METHOD**

- 1 - Position the pump on the Cambox, with the lever in the STOP position.
- 2 - Set the measuring instrument to zero.
- 3 - Move the control lever from the STOP position to the full stroke position (19 mm).
- 4 - Lock the control lever in position with a BOSCH lock pin.
- 5 - Fix the pump to the plunger assembly.
- 6 - Release the control lever by removing the BOSCH pin and move the plunger assembly to the STOP position (the control lever stroke should return to “zero”)
- 7 - Check that stroke distance from the STOP position to the full-stroke position is 19 mm.
- 8 - Check that injection starts at a plunger stroke position of 5.5 – 5.65 mm with a control rod stroke of 2 mm.

### 16.3 PISTONS - CONNECTING RODS

#### CAUTION

- 1 - The pistons and cylinder liners are divided into selection classes (A white - B red) to ensure matching pairs.
- 2 - When renewing the pistons and cylinder liners, make sure that all the assemblies (pistons + liners) belong to the same selection class.
- 3 - The class identification markings are stamped on the pistons and the liners in the positions «TECHNICAL DATA AND DIMENSIONS».

#### 16.3.1 Inspection of the pistons and piston rings

- 1 - After removing all carbon deposits and cleaning the pistons thoroughly, measure the outside diameter of the pistons using a micrometer. Measure at two positions "A" and "B" starting from the base of the skirt and at 90° to the axis of the gudgeon pin.

ENGINE	A	B
W 3-4-6 cylinders	10	57.25
WT 3 cylinders	9	58.3
WT 4-6 cylinders	9	58.3
WTI 4-6 cylinders	14	53.2

If the measurement is not within the tolerance limits indicated in «TECHNICAL DATA AND DIMENSIONS», renew the pistons.

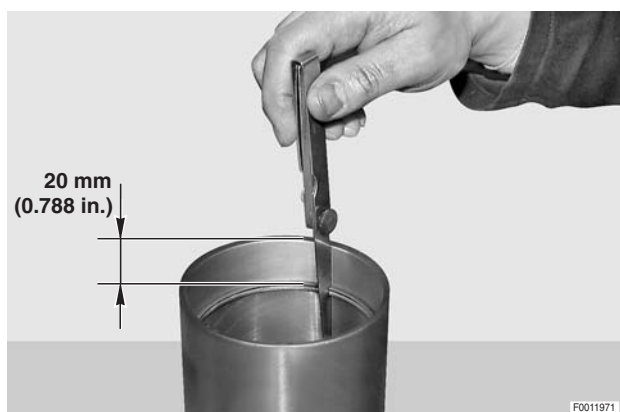
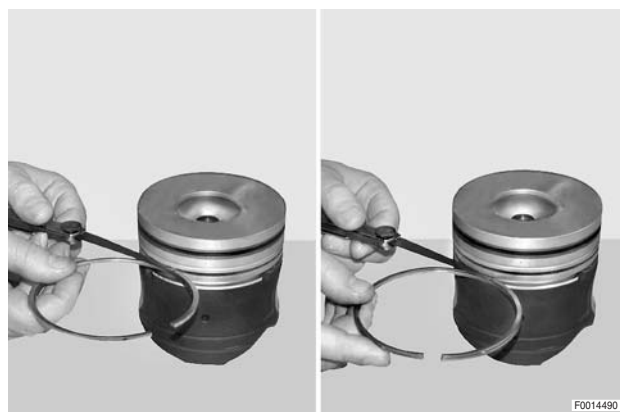
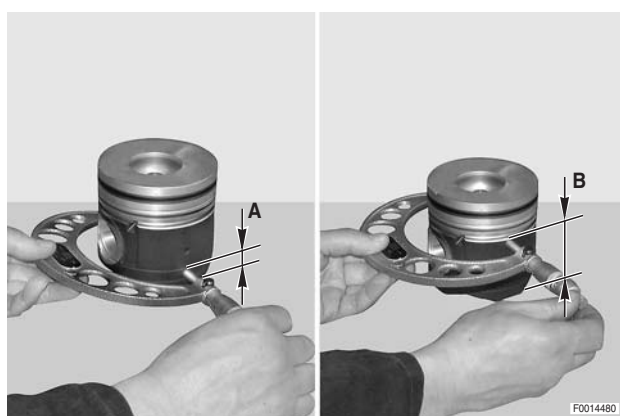
- 2 - Check the groove clearances of the second piston ring and the oil scraper ring. Use a feeler gauge and a new ring as shown in the figure.

★ The top piston ring has a tapered section and therefore it is not possible to check its groove clearance.

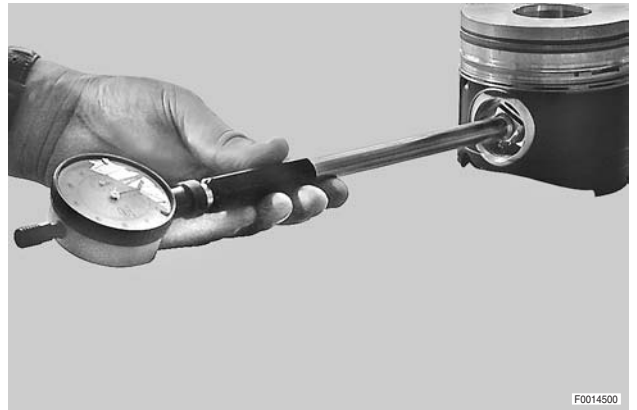
If the groove clearance of the second piston ring or the oil scraper ring exceeds the values specified in «TECHNICAL DATA AND DIMENSIONS», renew the piston.

- 3 - Clean the carbon deposits from the upper parts of the cylinder liners; insert the compression rings and oil scraper rings one at a time into the bottom end of the cylinder liner and check the end gap using a feeler gauge.
  - ★ Push the rings in by about 20 mm (0.788 in.) while keeping them square to the cylinder head.

If the end gaps are not within the tolerance limits indicated in «TECHNICAL DATA AND DIMENSIONS», renew the compression and oil scraper rings.



- 4 - Check the inside diameter of the bore for the gudgeon pin using a bore gauge.



### 16.3.2 Inspecting the connecting rods - gudgeon pins

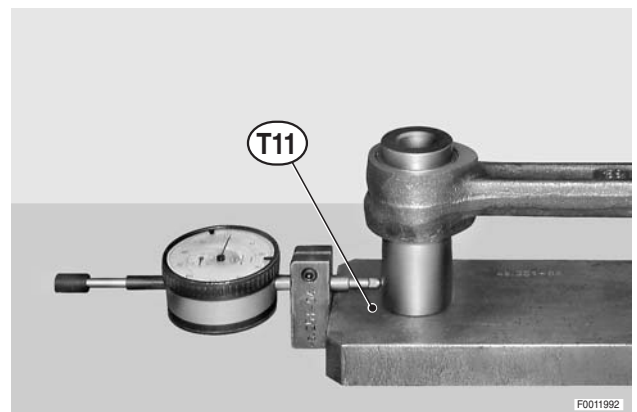
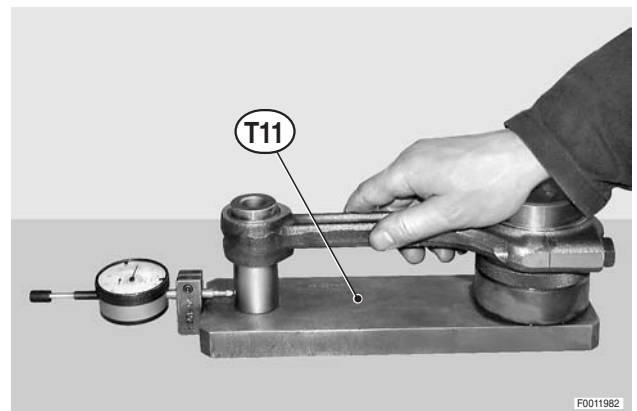
- 1 - Check the parallelism between the small-end and big-end axes of the connecting rod using tool **T11** (code 5.9030.651.4) and a dial gauge with the contact point resting on the gudgeon pin.  
The procedure is as follows:

- 1 - Fit the gudgeon pin and the big-end cap to the connecting rod.

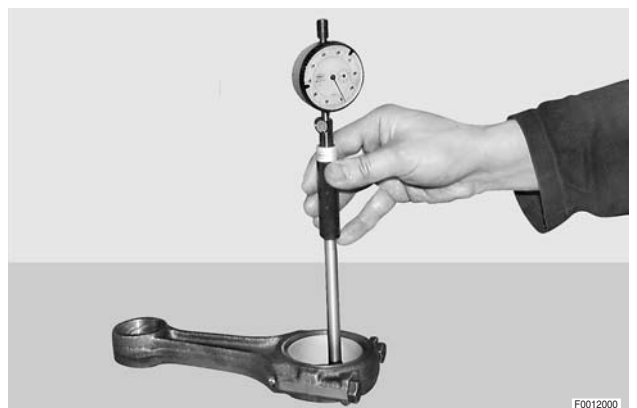
Bolts: 85 Nm (62.6 lb.ft.)

- 2 - Position the connecting rod on the tool, and rotate it in both directions; preload and zeroset the dial gauge at the point of maximum radius.
- 3 - Turn the connecting rod over and take the reading again. The difference between the two readings is the parallelism error. If the error is greater than the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», the connecting rod must be renewed.

**!** If one or more connecting rods are renewed, the weight of the new rods must be compared with that of the original rods that are reutilised; the maximum permissible weight difference between the lightest connecting rod and the heaviest is 20 g.



- 2 - Using a bore gauge, measure the inside diameter of the big-end shell bearing. If the bearing wear exceeds the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», renew the shell bearing.



- 3 - Using a bore gauge, measure the inside diameter of the small-end bush; if the bush wear exceeds the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», renew the bush.

**!** When inserting new small-end bushes, make sure that oil grooves and the splits in the bushes are positioned correctly.

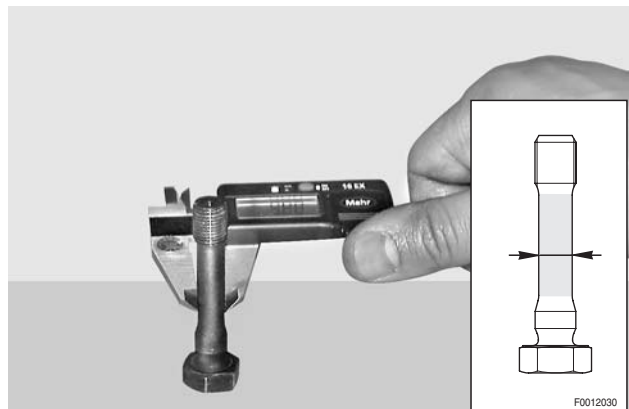


- 4 - Using a dial gauge, measure the outside diameters of the gudgeon pins; if the diameter of a gudgeon pin is not within the tolerance limits specified in «TECHNICAL DATA AND DIMENSIONS», renew the gudgeon pin.



#### 16.4 INSPECTION OF THE BIG-END CAP BOLTS

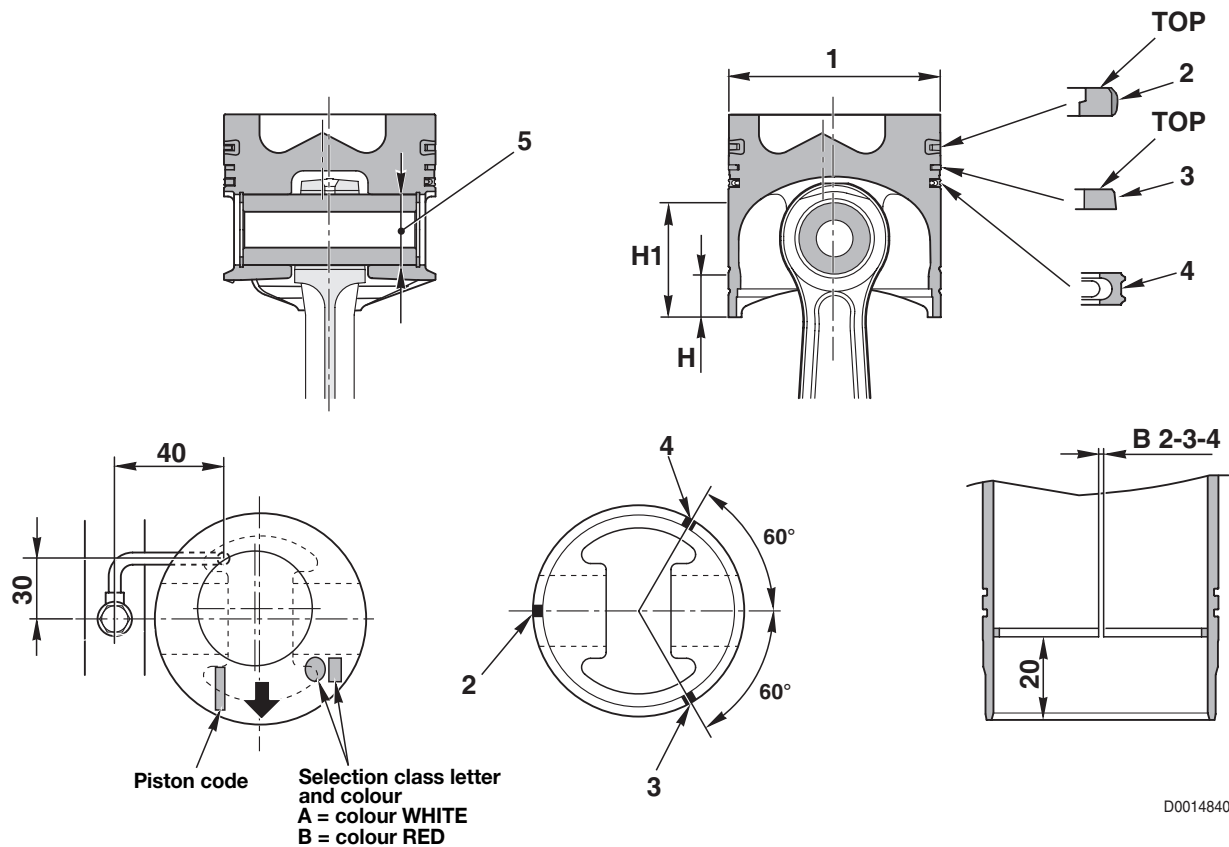
- 1 - Using a dial gauge or micrometer, measure the diameter of the bolts along the central reduced diameter section; the difference between the maximum and minimum diameter gives an indication of the stress to which the bolt has been subjected during previous tightenings.  
If the difference between the minimum and maximum diameter exceeds that indicated in the table «TECHNICAL DATA AND DIMENSIONS», renew the bolts.





PISTONS code 0.013.1456.0 (3-4-6 cylinder W engines)

## PISTON RINGS

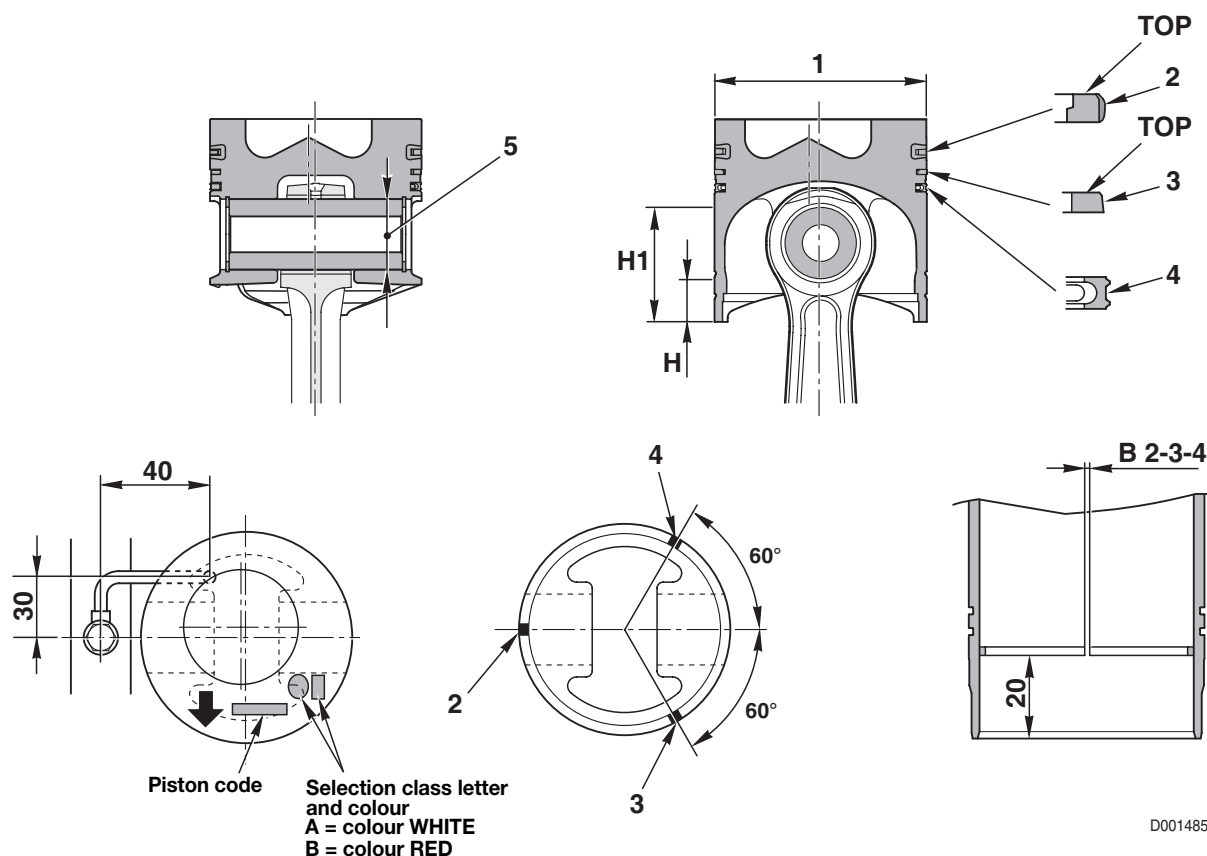


Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTE
1	Piston diameter (Distance from bottom of skirt: H = 10 mm (0.394 in.) H1 = 57.25 mm (2.256 in.)	Selection A H = 104.890 (4.1326) 104.902 (4.1331) H1 = 104.760 (4.1275) 104.772 (4.1280)	104.680 (4.1244)	
		Selection B H = 104.900 (4.1330) 104.912 (1.1335) H1 = 104.630 (4.1224) 104.642 (4.1228)	104.680 (4.1244)	
2	Piston-ring side clearance	Top 0.11 – 0.145 (0.00433 – 0.0057)	0.2 (0.00788)	Barrelled face, chromium plated torsional
		Second 0.050 – 0.085 (0.0020 – 0.0033)	0.150 (0.006)	Wedge section 90°I
		Oil scraper 0.030 (0.0012) 0.065 (0.0026)	0.150 (0.006)	Chromium plated
	Piston-ring end gap "B"	Top 0.40 – 0.65 (0.016 – 0.026)	1.5 (0.06)	
		Second 0.40 – 0.65 (0.016 – 0.026)	1.5 (0.06)	
		Oil scraper 0.30 – 0.60 (0.012 – 0.024)	1.5 (0.06)	
5	Outside diameter of gudgeon pin	34.99 – 34.984 (1.3786 – 1.3784)	34.960 (1.3774)	
	Inside diameter of gudgeon pin bores	35.012 (1.3795) 35.006 (1.3792)	35.020 (1.3798)	

PISTONS code 0.012.8912.0 ( 3- cylinder WT engines)

## PISTON RINGS

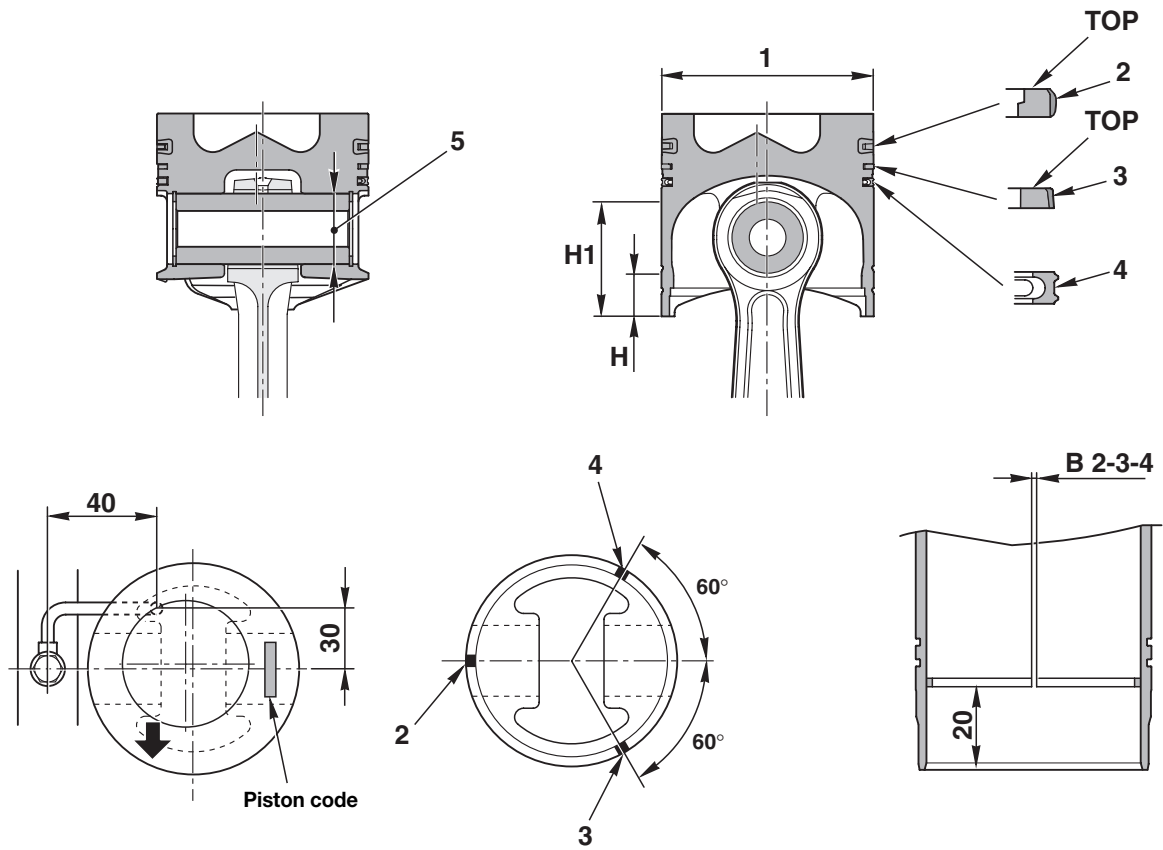


Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTE
1	Piston diameter (Distance from bottom of skirt: <b>H</b> = 9 mm (0.3546 in.) <b>H1</b> = 58.3 mm (2.297 in.)	Selection A <b>H</b> = 104.890 (4.1326) 104.902 (4.1331)	104.680 (4.1244)	
			<b>H1</b> = 104.765 (4.1277) 104.777 (4.1282)	
		Selection B <b>H</b> = 104.900 (4.1330) 104.912 (4.1335)	104.680 (4.1244)	
			<b>H1</b> = 104.630 (4.1224) 104.642 (4.1228)	
2 3 4	Piston-ring side clearance	Top	–	Barrelled face, chromium plated torsional
		Second	0.050 – 0.082 (0.0020 – 0.0032)	Wedge section 90°I
		Oil scraper	0.030 (0.0012) 0.065 (0.0026)	Chromium plated
	Piston-ring end gap "B"	Top	0.40 – 0.65 (0.016 – 0.026)	
		Second	0.40 – 0.65 (0.016 – 0.026)	
		Oil scraper	0.30 – 0.60 (0.012 – 0.024)	
5	Outside diameter of gudgeon pin	34.99 – 34.984 (1.3786 – 1.3784)	34.960 (1.3774)	
	Inside diameter of gudgeon pin bores	35.012 (1.3795) 35.006 (1.3792)	35.020 (1.3798)	

PISTONS code 0.012.8913.0 ( 4-6 cylinder WT engines)

## PISTON RINGS



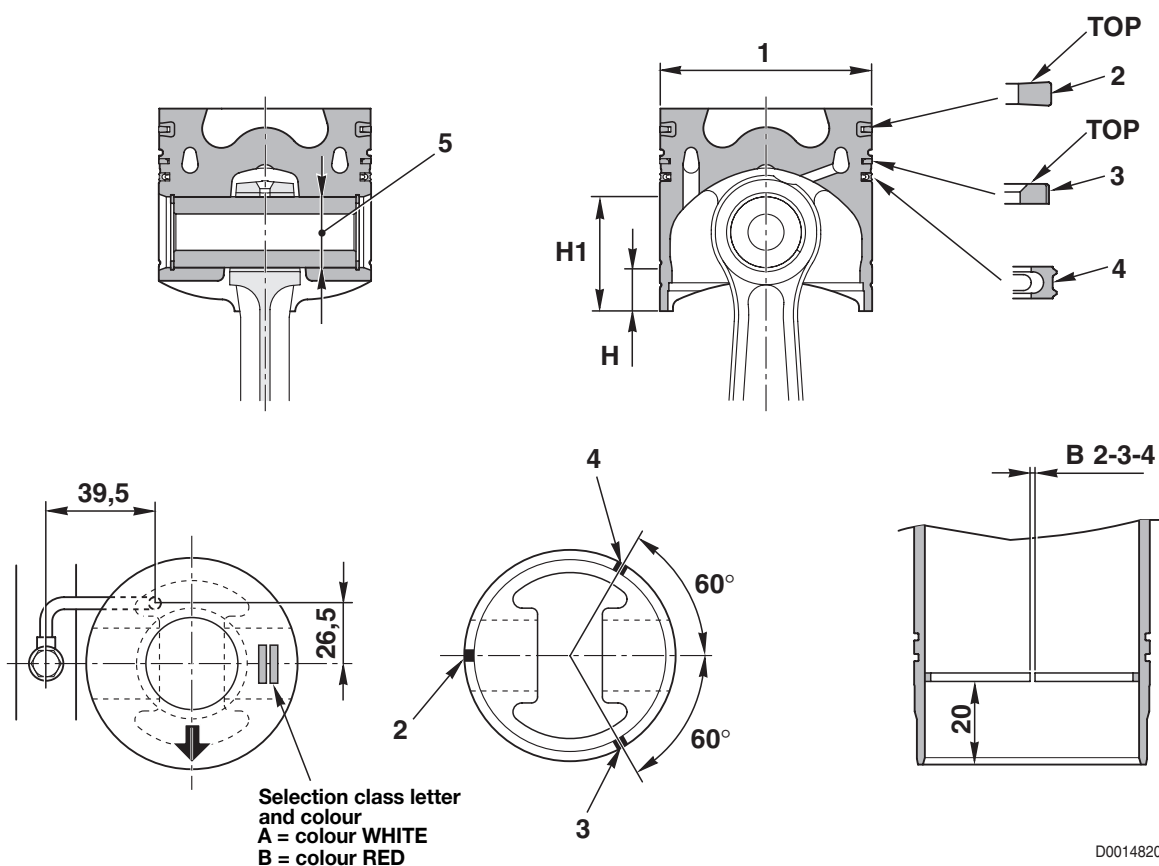
D0014830

Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTE	
1	Piston diameter (Distance from bottom of skirt: <b>H</b> = 9 mm (0.3546 in.) <b>H1</b> = 58.3 mm (2.297 in.)	<b>H</b> = 104.907 (4.1333) 104.893 (4.1328)	104.680 (4.1244)		
		<b>H1</b> = 104.784 (4.1285) 104.766 (4.1278)	104.550 (4.1193)		
2  3  4	Piston-ring side clearance	Top	0.11 –0.145 (0.00433 –0.0057)	0.2 (0.00788)	Barrelled face, chromium plated torsional
		Second	0.070 (0.0027) 0.105 (0.0041)	0.150 (0.006)	Wedge section 90° chromium plated
		Oil scraper	0.030 (0.0012) 0.065 (0.0026)	0.150 (0.006)	Chromium plated
	Piston-ring end gap "B"	Top	0.40 –0.65 (0.016 –0.026)	1.5 (0.06)	
		Second	0.30 –0.50 (0.012 –0.020)	1.5 (0.06)	
		Oil scraper	0.30 –0.60 (0.012 –0.024)	1.5 (0.06)	
5	Outside diameter of gudgeon pin	34.99 – 34.984 (1.3786 –1.3784)	34.960 (1.3774)		
	Inside diameter of gudgeon pin bores	35.012 (1.3795) 35.006 (1.3792)	35.020 (1.3798)		

PISTONS code 0.012.8483.4/20 (4-6 cylinder WTI engines)

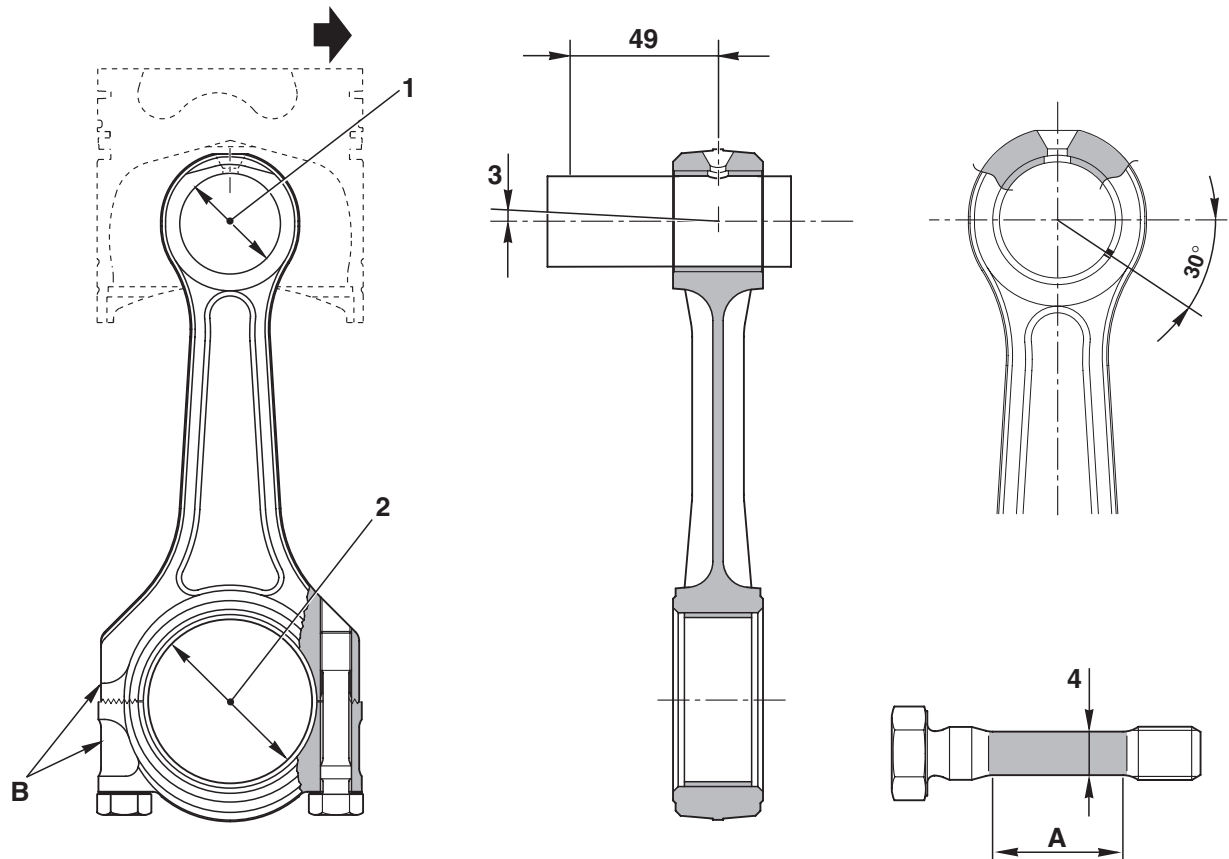
## PISTON RINGS



Unit of measurement: mm (in.)

Pos.	Dimensions		Normal measurement	Tolerance limit	NOTE
1	Piston diameter (Distance from bottom of skirt: H = 14 mm (0.552 in.) H1 = 53.2 mm (2.096 in.)	Class A	H = 104.892 (4.1327) 104.880 (4.1322)	104.680 (4.1244)	
			H1= 104.812 (4.1296) 104.800 (4.1291)	104.600 (4.1212)	
		Class B	H = 104.902 (4.1331) 104.890 (4.1326)	104.680 (4.1244)	
			H1= 104.822 (4.1299) 104.800 (4.1291)	104.600 (4.1212)	
2 3 4	Piston-ring side clearance	Top	–	–	Trapezoid 6° chromium plated
		Second	0.070 (0.0027) 0.105 (0.0041)	0.150 (0.006)	Barrelled face asymmetric torsional chromium plated
		Oil scraper	0.030 (0.0012) 0.065 (0.0026)	0.150 (0.006)	Chromium plated
	Piston-ring end gap "B"	Top	0.40 – 0.65 (0.016 – 0.026)	1.5 (0.06)	
		Second	0.40 – 0.65 (0.016 – 0.026)	1.5 (0.06)	
		Oil scraper	0.30 – 0.50 (0.012 – 0.020)	1.5 (0.06)	
	5	Outside diameter of gudgeon pin	34.99 – 34.984 (1.3786 – 1.3784)	34.960 (1.3774)	
Inside diameter of gudgeon pin bores		35.012 (1.3795) 35.006 (1.3792)	35.020 (1.3798)		

## CONNECTING RODS (FOR PISTONS W-WT)



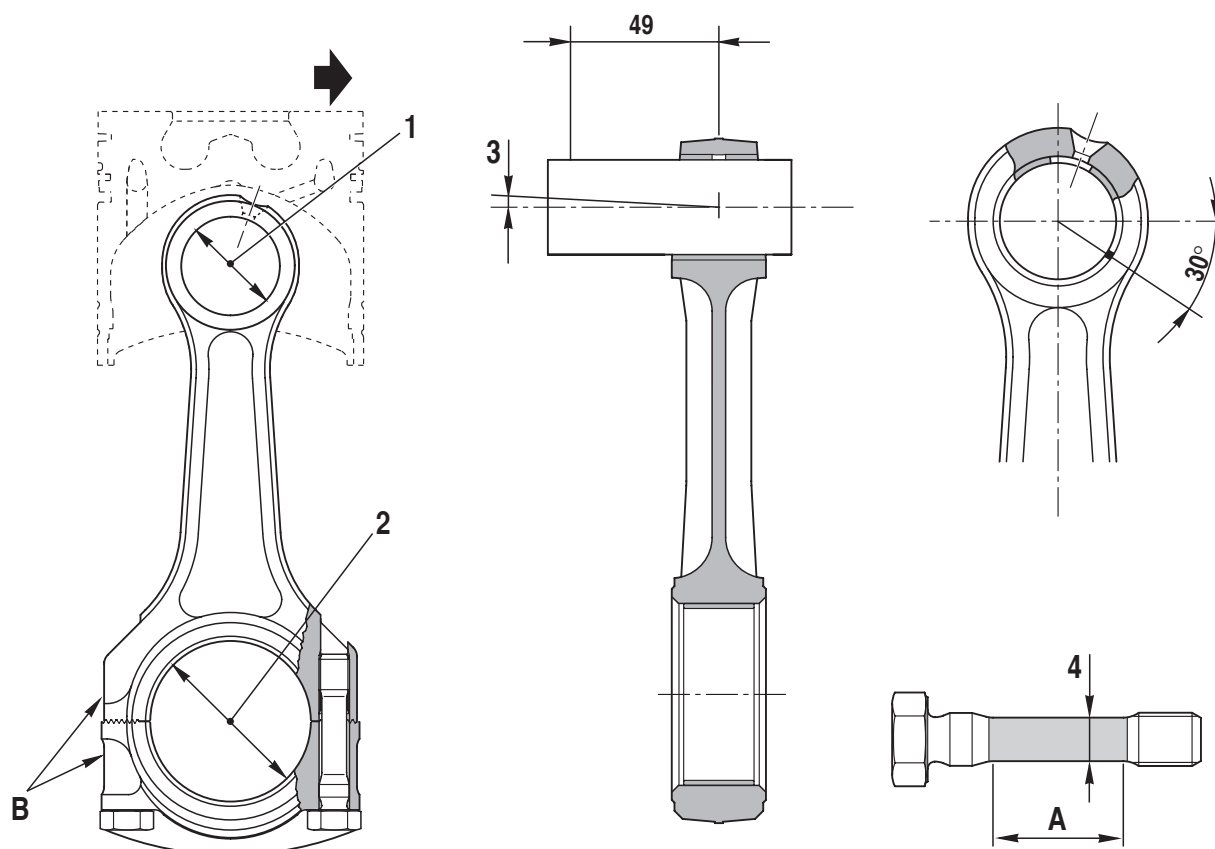
D0007320

Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Inside diameter of small-end bush	35.015 (1.3796) 35.025 (1.3800)	35.060 (1.3814)	
2	Inside diameter of big-end bearing	63.535 (2.5033) 65.575 (2.5836)	63.620 (2.5066)	
	1st undersize (regrinding)	63.285 (2.49349) 63.325 (2.4950)	63.370 (2.4968)	
	2nd undersize (regrinding)	63.035 (2.4836) 63.075 (2.4851)	63.120 (2.4870)	
3	Parallelism of connecting rod axes (measured at 49 mm from the longitudinal axis)	—	Max. 0.08 (Max. 0.0032)	
4	Difference in diameter in section A of bolt	—	Max. 0.1 (Max. 0.004)	
5	Difference in weight between connecting rods	—	Max. 20 g	



## CONNECTING RODS (FOR PISTONS WTI)



D0007350

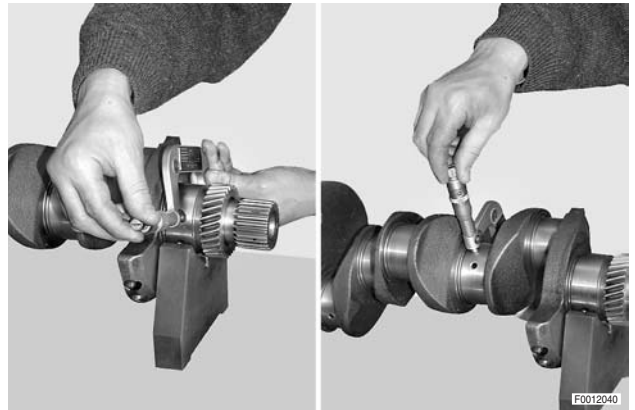
Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Inside diameter of small-end bush	35.015 (1.3796) 35.025 (1.3800)	35.060 (1.3814)	
2	Inside diameter of big-end bearing	63.535 (2.5033) 65.575 (2.5836)	63.620 (2.5066)	
	1st undersize (regrinding)	63.285 (2.49349) 63.325 (2.4950)	63.370 (2.4968)	
	2nd undersize (regrinding)	63.035 (2.4836) 63.075 (2.4851)	63.120 (2.4870)	
3	Parallelism of connecting rod axes (measured at 49 mm from the longitudinal axis)	—	Max. 0.08 (Max. 0.0032)	
4	Difference in diameter in section A of bolt	—	Max. 0.1 (Max. 0.004)	
5	Difference in weight between connecting rods	—	Max. 20 g	

## 16.5 CRANKSHAFT

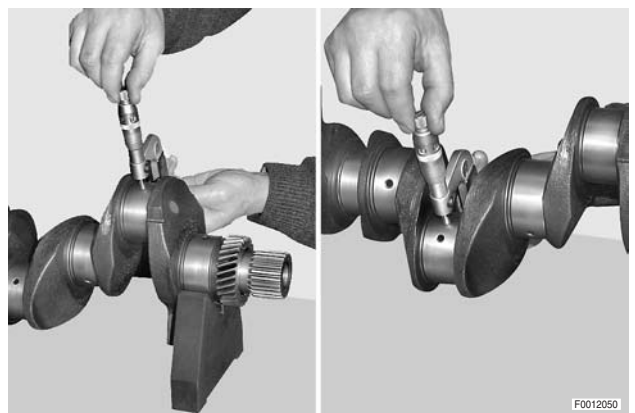
- 1 - Using a micrometer, measure the diameters of the main bearing journals and the crankpins.

★ Measure the diameter of each journal at several points around the entire circumference to detect taper and out-of-round errors.



- 2 - If the dimensional errors of even just one journal exceed the tolerance limits specified in the «TECHNICAL DATA AND DIMENSIONS» the entire crankshaft will have to be reground, and the diameters of the journals reduced to one of the specified undersizes.

★ If the crankshaft is reground, it will be necessary to fit new big-end and main shell bearings.

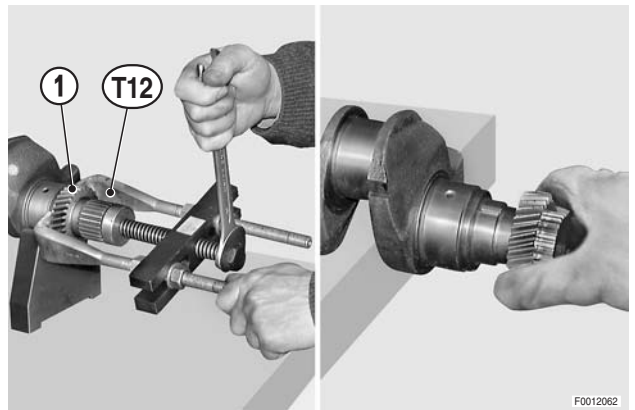


### Only if necessary

- 3 - Using puller **T12** (code 5.9030.008.4/10) remove the timing gear (1) from the crankshaft

- 4 - Heat the new timing gear on a hot plate and fit it on the crankshaft, ensuring that it is positioned up against the shoulder.

★ Check the condition of the key.

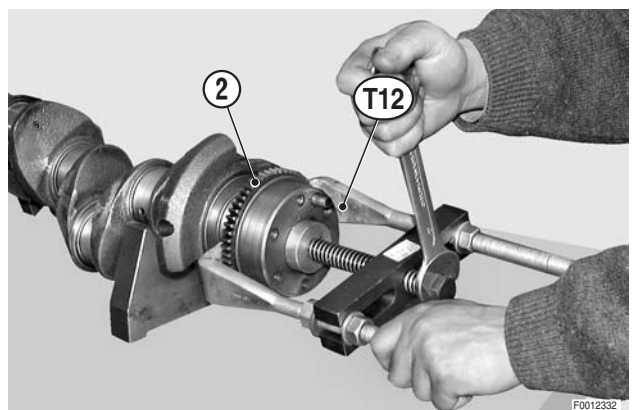


### 6-cylinder version

**If necessary, replace the lubrication oil pump drive gear.**

- 5 - Using puller **T12** (code 5.9030.008.4/10), remove the oil pump drive gear (2).

★ Remove all traces of old sealant from the crankshaft.



6 - Heat the new gear on a thermostatic hotplate to a temperature 100°C greater than that of the crankshaft.

7 - Apply sealant to the gear contact surfaces of the crankshaft.

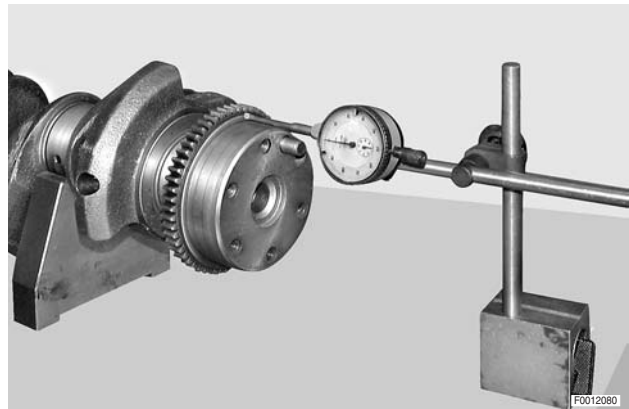
🔧 Crankshaft: Loctite 648

8 - Fit the gear (2) onto the crankshaft (3) so that it is a distance "A" from the crankshaft shoulder (3).

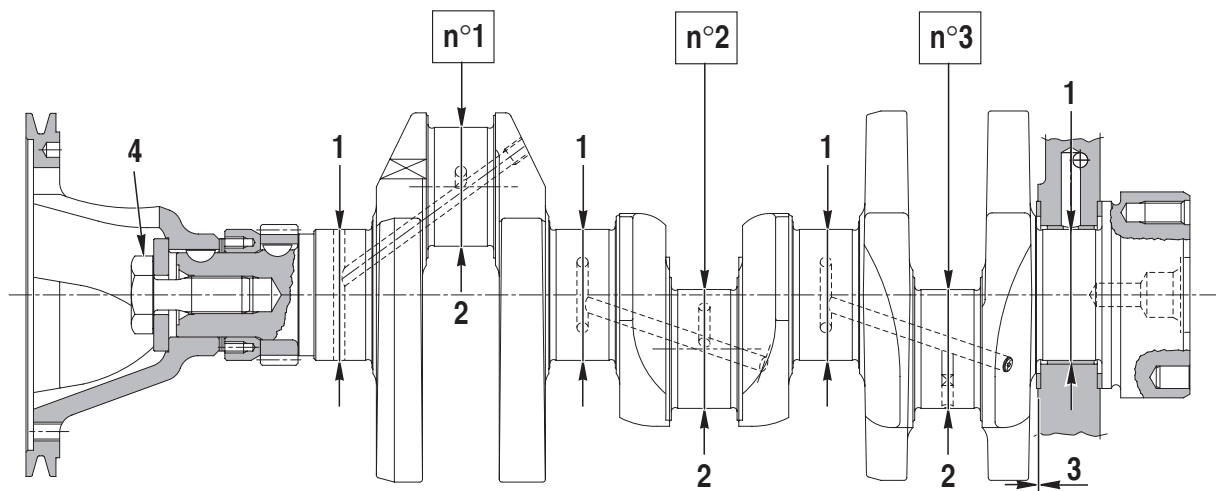
★ **A** = 0.2–0.5 mm (0.079–0.197 in.).

9 - When the gear has cooled, remove the excess sealant and check that the **side play** of the gear does not exceed 0.1 mm (0.004 in.) when measured in correspondence with the Ø116 mm (4.56 in.).

★ If the side play exceeds 0.1 mm (0.004 in.), using a soft metal punch (copper, aluminium, brass), move the gear to within the tolerance limits.



## CRANKSHAFT (3-CYLINDER VERSION)



D0007360

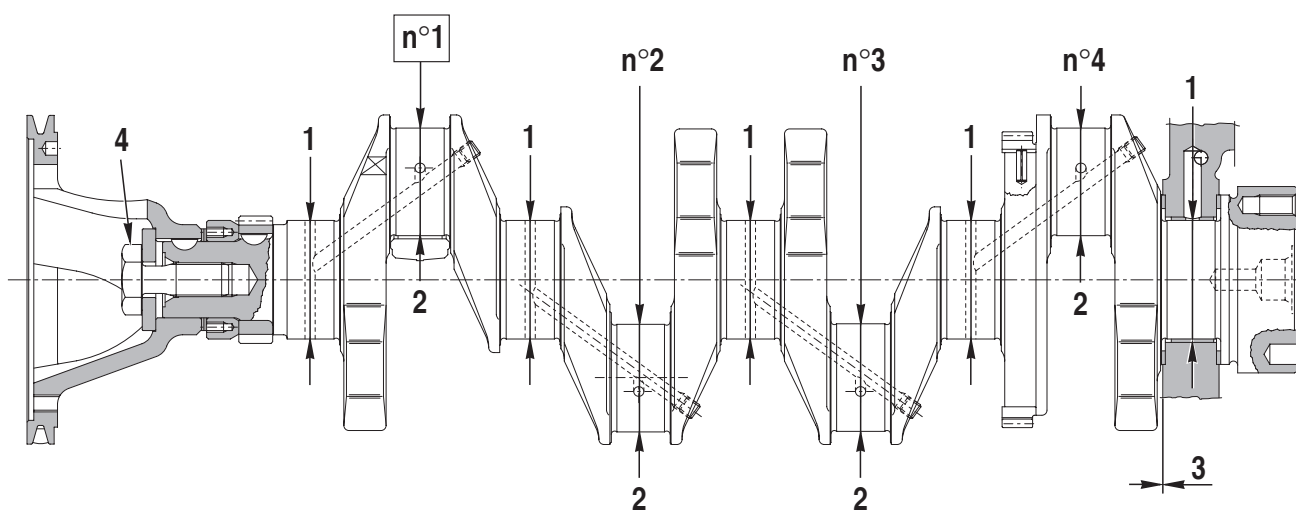
Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Main bearing journal diameter	69.98 – 69.96 (2.7572 – 2.7564)	69.90 (2.7541)	
	1st undersize (regrinding)	69.73 – 69.71 (2.7474 – 2.7466)	69.65 (2.7442)	
	2nd undersize (regrinding)	69.48 – 69.46 (2.7375 – 2.7367)	69.40 (2.7344)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
2	Crankpin diameter	63.50 – 63.48 (2.5019 – 2.5011)	63.40 (2.4980)	
	1st undersize (regrinding)	63.25 – 63.23 (2.4920 – 2.4913)	63.15 (2.4881)	
	2nd undersize (regrinding)	63.00 – 62.98 (2.4822 – 2.4814)	62.90 (2.4783)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
3	Crankshaft endfloat	0.105–0.300 (0.0041 – 0.0118)	0.500 (0.020)	
	Thrust washers	1st assembly	–	
		1st oversize	+0.250 (+0.01)	
		2nd oversize	+0.500 (+0.02)	
4	Crankshaft pulley tightening torque	See «ENGINE ASSEMBLY»		

## NOTES FOR REGRINDING

- 1 - Before regrinding the crankshaft, check for cracks using a penetrating liquid.  
If even the smallest crack is detected the crankshaft must be discarded.
- 2 - If the crankshaft is reground to one of the specified undersizes, it will not be necessary to restore the journal fillets.  
★ Do not cut into the existing fillet radii.
- 3 - During regrinding, the crankshaft should preferably be rotated in the opposite direction to its normal rotation in service; however, it is still acceptable for the crankshaft to be rotated in its normal operating direction.
- 4 - During polishing, the crankshaft must be rotated **only** in the same direction as its normal rotation in service.
- 5 - The surfaces of the crankshaft journals must be totally smooth ( $Ra=0.25 \mu m$ )

## CRANKSHAFT (4-CYLINDER VERSION)



D0007370

Unit of measurement: mm (in.)

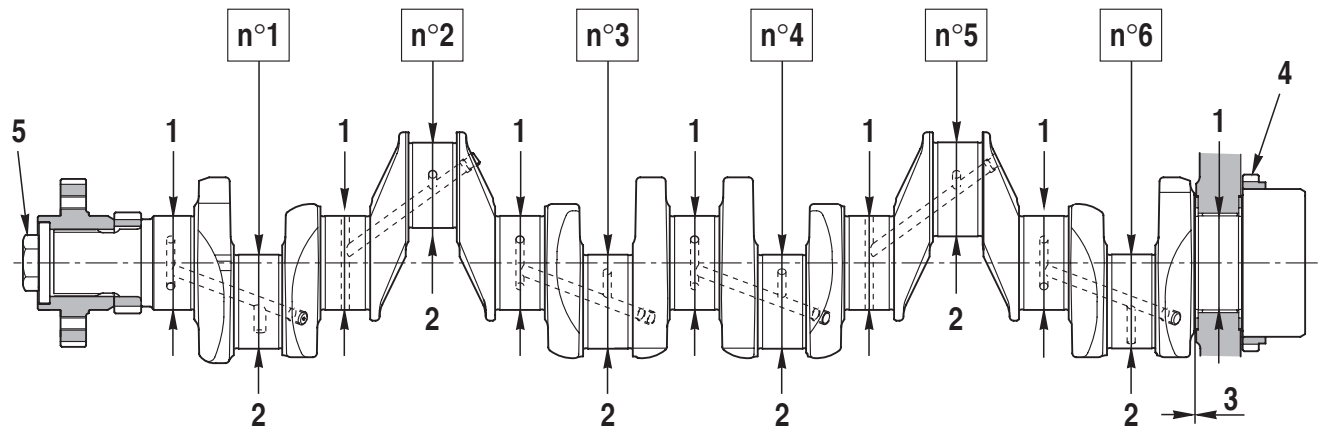
Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Main bearing journal diameter	69.98 – 69.96 (2.7572 – 2.7564)	69.90 (2.7541)	
	1st undersize (regrinding)	69.73 – 69.71 (2.7474 – 2.7466)	69.65 (2.7442)	
	2nd undersize (regrinding)	69.48 – 69.46 (2.7375 – 2.7367)	69.40 (2.7344)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
2	Crankpin diameter	63.50 – 63.48 (2.5019 – 2.5011)	63.40 (2.4980)	
	1st undersize (regrinding)	63.25 – 63.23 (2.4920 – 2.4913)	63.15 (2.4881)	
	2nd undersize (regrinding)	63.00 – 62.98 (2.4822 – 2.4814)	62.90 (2.4783)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
3	Crankshaft endfloat	0.105 – 0.300 (0.0041 – 0.0118)	0.500 (0.020)	
	Thrust washers	1st assembly	–	
		1st oversize	+0.250 (+0.01)	
		2nd oversize	+0.500 (+0.02)	
4	Crankshaft pulley tightening torque	See «ENGINE ASSEMBLY»		

## NOTES FOR REGRINDING

- 1 - Before regrinding the crankshaft, check for cracks using a penetrating liquid.  
If even the smallest crack is detected the crankshaft must be discarded.
- 2 - If the crankshaft is reground to one of the specified undersizes, it will not be necessary to restore the journal fillets.  
★ Do not cut into the existing fillet radii.
- 3 - During regrinding, the crankshaft should preferably be rotated in the opposite direction to its normal rotation in service; however, it is still acceptable for the crankshaft to be rotated in its normal operating direction.
- 4 - During polishing, the crankshaft must be rotated **only** in the same direction as its normal rotation in service.
- 5 - The surfaces of the crankshaft journals must be totally smooth (Ra=0.25 µm)



## CRANKSHAFT (6-CYLINDER VERSION)



D0001140

Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Main bearing journal diameter	69.98 – 69.96 (2.7572 – 2.7564)	69.90 (2.7541)	
	1st undersize (regrinding)	69.73 – 69.71 (2.7474 – 2.7466)	69.65 (2.7442)	
	2nd undersize (regrinding)	69.48 – 69.46 (2.7375 – 2.7367)	69.40 (2.7344)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
2	Crankpin diameter	63.50 – 63.48 (2.5019 – 2.5011)	63.40 (2.4980)	
	1st undersize (regrinding)	63.25 – 63.23 (2.4920 – 2.4913)	63.15 (2.4881)	
	2nd undersize (regrinding)	63.00 – 62.98 (2.4822 – 2.4814)	62.90 (2.4783)	
	Permitted taper	Max. 0.030 (Max. 0.0012)	0.050 (0.002)	
	Permitted ovality	Max. 0.005 (Max. 0.0002)	0.050 (0.002)	
3	Crankshaft endfloat	0.105–0.300 (0.0041 – 0.0118)	0.500 (0.020)	
	1st assembly	–	–	
	Thrust washers 1st oversize	+0.250 (+0.01)	–	
	2nd oversize	+0.500 (+0.02)	–	
4	Crankshaft pulley tightening torque	Max. 0.1 (Max. 0.004)	Max. 0.1 (Max. 0.004)	
5	Main bearing journal diameter	See «ENGINE ASSEMBLY»		

## NOTES FOR REGRINDING

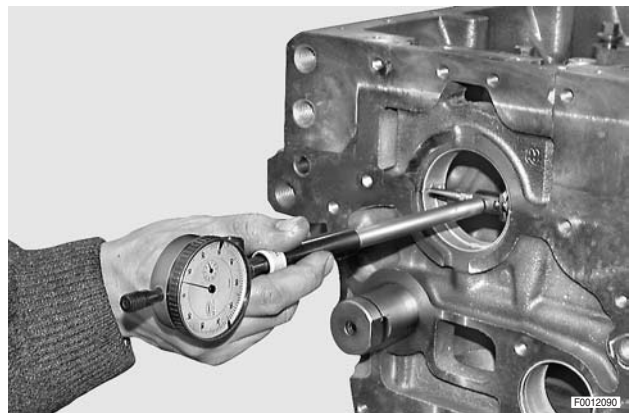
- 1 - Before regrinding the crankshaft, check for cracks using a penetrating liquid.  
If even the smallest crack is detected the crankshaft must be discarded.
- 2 - If the crankshaft is reground to one of the specified undersizes, it will not be necessary to restore the journal fillets.  
★ Do not cut into the existing fillet radii.
- 3 - During regrinding, the crankshaft should preferably be rotated in the opposite direction to its normal rotation in service; however, it is still acceptable for the crankshaft to be rotated in its normal operating direction.
- 4 - During polishing, the crankshaft must be rotated **only** in the same direction as its normal rotation in service.
- 5 - The surfaces of the crankshaft journals must be totally smooth ( $R_a=0.25 \mu\text{m}$ )

## 16.6 ENGINE BLOCK - CYLINDER LINERS

### 16.6.1 Engine block

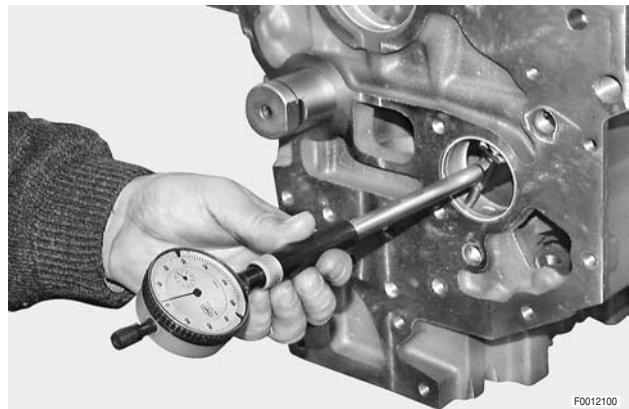
- 1 - Fit the main bearing caps complete with their half shells to the engine block.
  - ★ Position the caps and half shells in accordance with their identification numbers and the positioning marks made during dismantling.
- 2 - Tighten down the bearing cap bolts.
  - 🔧 Bolts: 92 Nm (67.8 lb.ft.)

- 3 - Using a telescopic bore gauge with dial, measure the inside diameters of the main bearings and check for ovality.
  - ★ Note down the measurements taken for each bearing, and if the diameters exceed the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», they must be renewed.
  - ★ Undersize main shell bearings must be fitted each time the crankshaft is reground.



- 4 - Using a bore gauge with dial, measure the diameters of the camshaft shell bearings.
  - ★ If the diameters of the shell exceed the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS» the bearings must be renewed and the new bearings must be reamed after fitting.
  - ★ To facilitate removal of the old bearings and reaming of the new ones, remove the plug on the fly-wheel side of the engine block. On completion of the operations, fit a new plug coated with sealant.

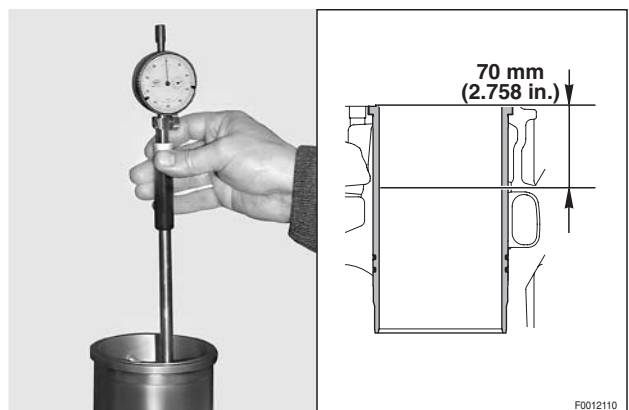
🔧 Plug: Loctite 554



### 16.6.2 Inspection of the cylinder liners

- 1 - After carefully removing all carbon deposits, measure the inside diameters of the cylinder liners using a bore gauge with dial. The measurements should be taken at a depth of 70 mm (2.758 in.) from the top of the cylinder liner and at 90° intervals around the circumference.

If the diameter of a cylinder liner exceeds the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», the liner must be renewed.



- !** Check carefully that all the new liners are from the same selection class as the corresponding pistons (class A or B).  
The selection class is stamped at the bottom of the liner as shown in the figure and indicated in «TECHNICAL DATA AND DIMENSIONS».

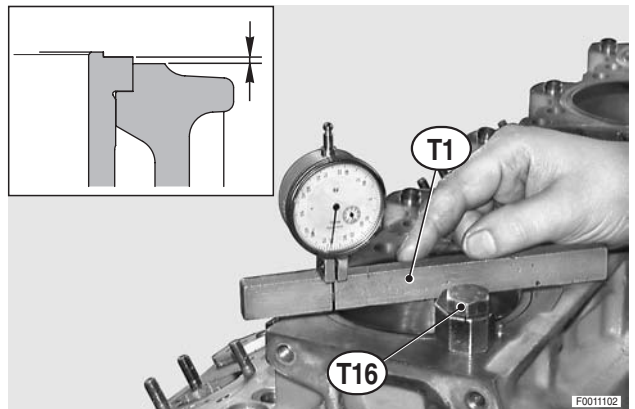


- 2 - If new compression and scraper rings are to be fitted, check that crosshatch honing pattern is still visible on the internal surfaces of cylinder liners; if the pattern is not present (even partially worn), then the liners will have be honed by a specialised machine shop to recreate the correct surface finish with the specified crosshatch angle using tool **T13** (code 5.9030.349.0.01).



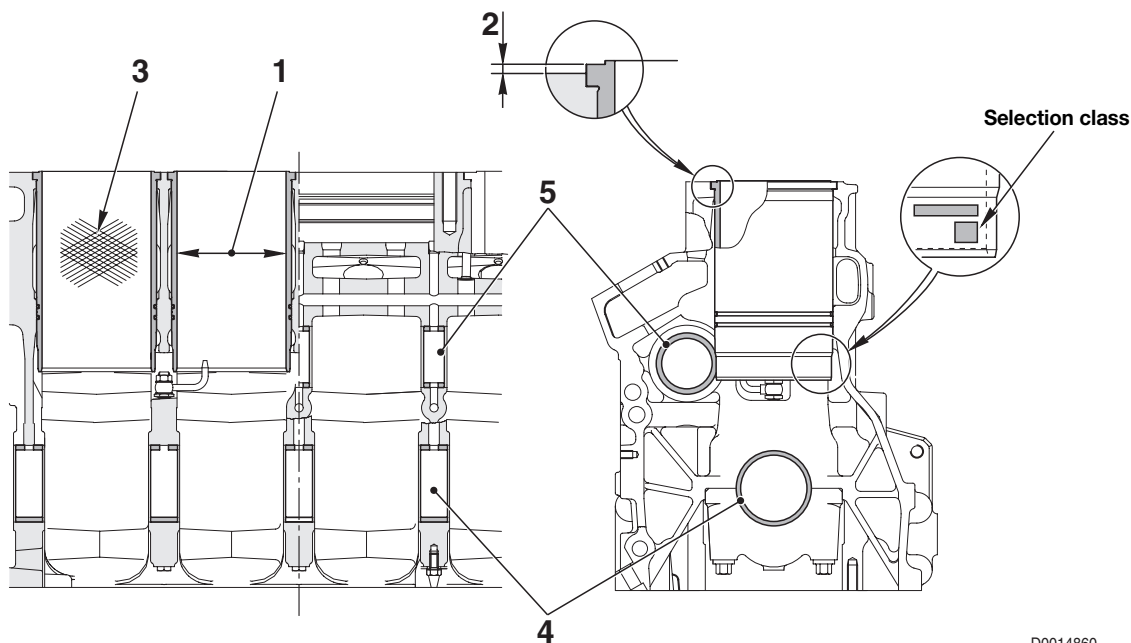
- 3 - Before final assembly of new cylinder liners in the engine block, remove all traces of old sealant, insert the liners without the O-rings and fix in position with blocks **T16** (code 5.9030.631.4/10).  
Using tool **T2** (code 5.9030.433.0) check that the nip clearance is as specified in «TECHNICAL DATA AND DIMENSIONS».

- !** To assemble the liners in the engine block, follow the instructions given in the section «ENGINE ASSEMBLY».



## ENGINE BLOCK - CYLINDERS

**NOTE.** The figure shows the cylinder block for the 6-cylinder engine; the dimensions indicated apply to all cylinder blocks.



D0014860

**NOTE.** Always check the cylinder class

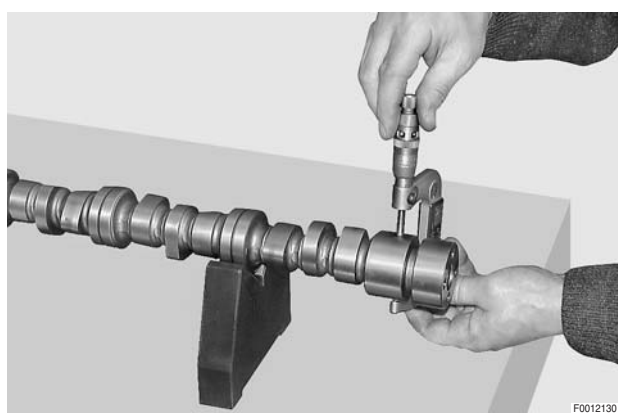
Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Maximum tolerance limit	NOTES	Pos.
1	Cylinder diameter distance from liner top: A= 70 mm (2.758 in.)	Class A	105.000 (4.1370) 105.022 (4.1379)	105.100 (4.1410)	
		Class B			
	Cylinder ovality		0.020 (0.0008)	Max. 0.080 (Max. 0.0032)	
2	Nip clearance		0.020 – 0.090 (0.0008 – 0.0035)	–	
3	Cross-hatch angle of honed internal finish ( $\alpha^\circ$ )		40 – 50°	40 – 50°	Roughness index Ra 0.2 – 0.6 $\mu\text{m}$
4	Main bearing shell diameter		70.018 – 70.068 (2.7587 – 2.7607)	70.130 (2.7631)	
	1st undersize (regrinding)		69.768 – 69.818 (2.7488 – 2.7508)	69.880 (2.7139)	
	2nd undersize (regrinding)		69.518 – 69.568 (2.7390 – 2.7410)	69.650 (2.7442)	
5	Camshaft bearing diameter		55.060 – 55.090 (2.1694 – 2.1705)	55.180 (2.1741)	
	Clearance between bearing and camshaft		0.060 – 0.120 (0.0024 – 0.0047)		

## 16.7 CAMSHAFT

- 1 - Carefully examine the surfaces of the cams; they should be perfectly polished and free of scoring, pitting and scuff marks.  
Any defects will necessitate renewal of the camshaft.

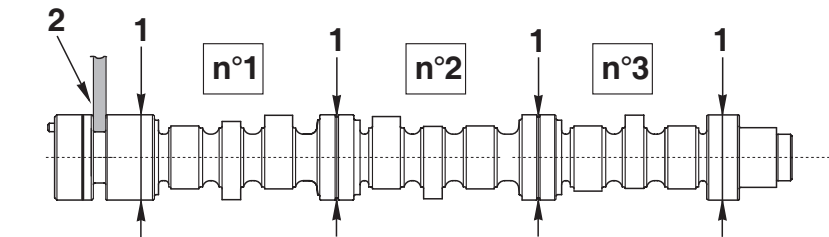
- 2 - Using a micrometer, measure the diameters of the camshaft journals and check for out-of-round. If any of the camshaft journals is out of the tolerance limits specified in «TECHNICAL DATA AND DIMENSIONS», the camshaft must be renewed.



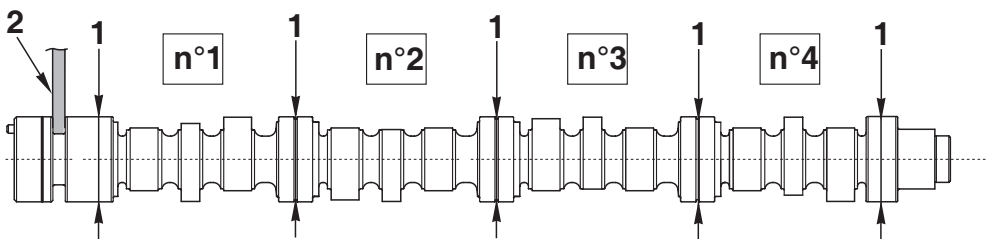


CAMSHAFT (13° STATIC ADVANCE)

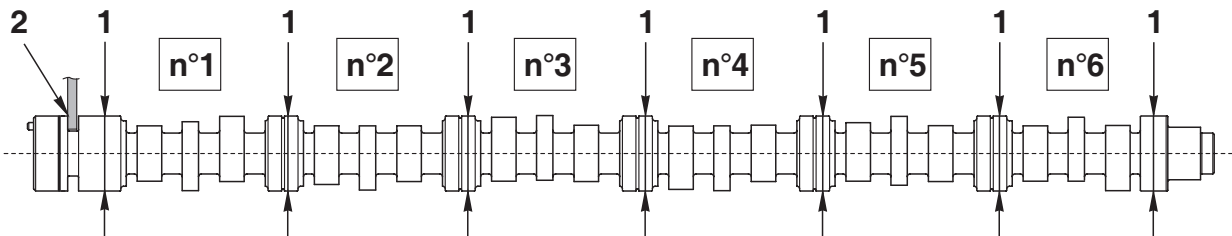
3-CYLINDERS



4-CYLINDERS



6-CYLINDERS



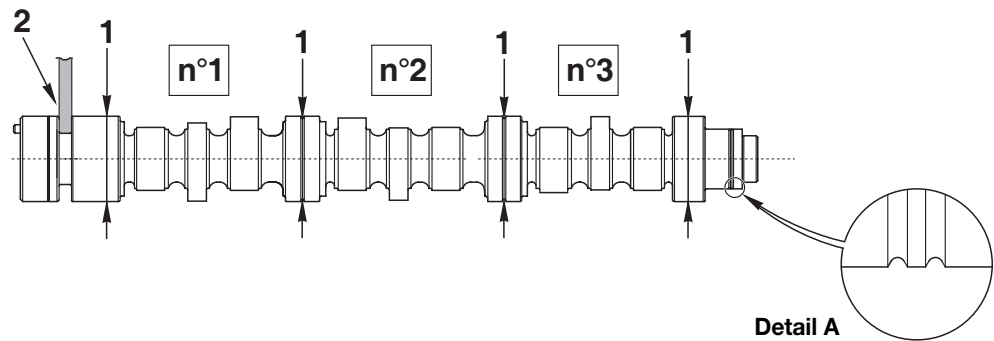
D0014870

Unit of measurement: mm (in.)

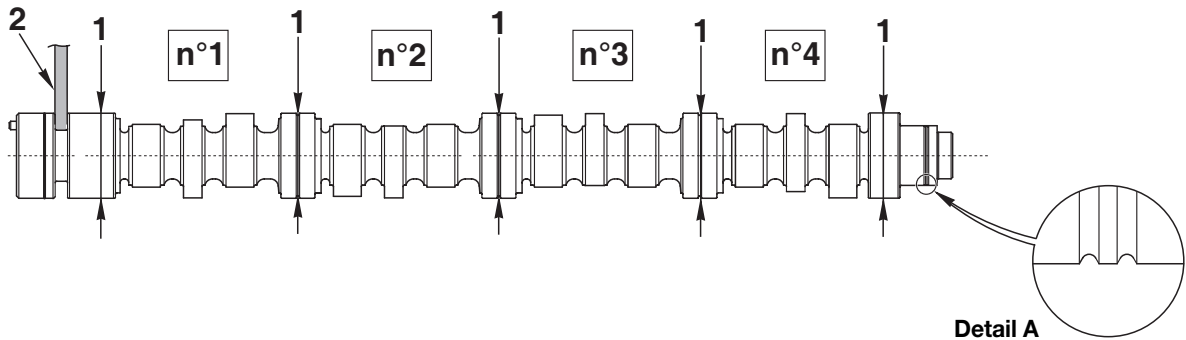
Pos.	Dimensions	Normal measurement	Maximum tolerance limit	NOTES
1	Camshaft journal	54.970 – 55.000 (2.1658 – 2.1670)	55.950 (2.2044)	
2	Endfloat	0.08 – 0.206 (0.0032 – 0.0081)	Max. 0.25 (Max. 0.001)	

CAMSHAFT (16° STATIC ADVANCE)

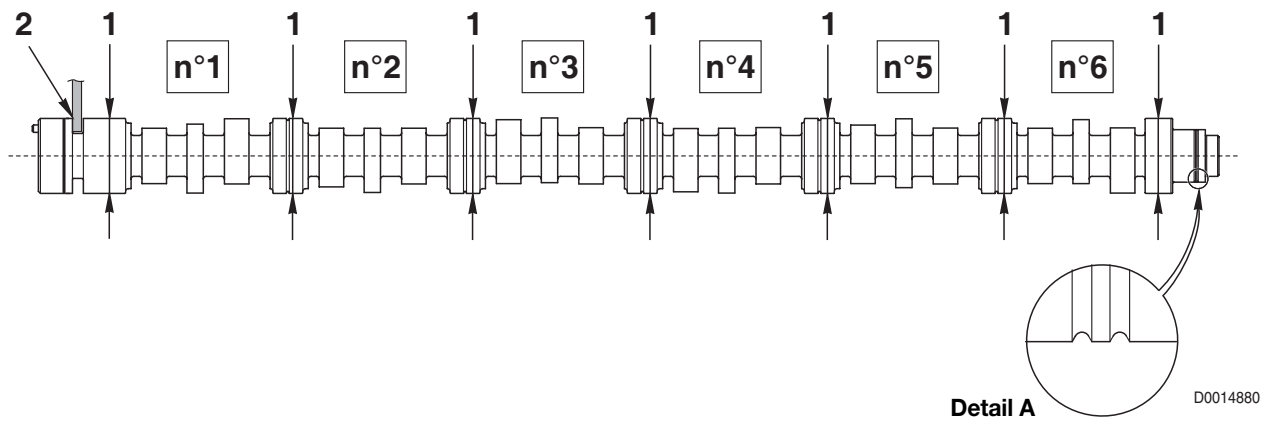
3-CYLINDERS



4-CYLINDERS



6-CYLINDERS

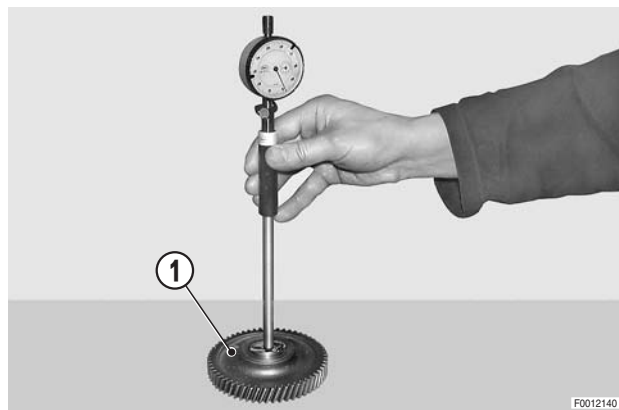


Unit of measurement: mm (in.)

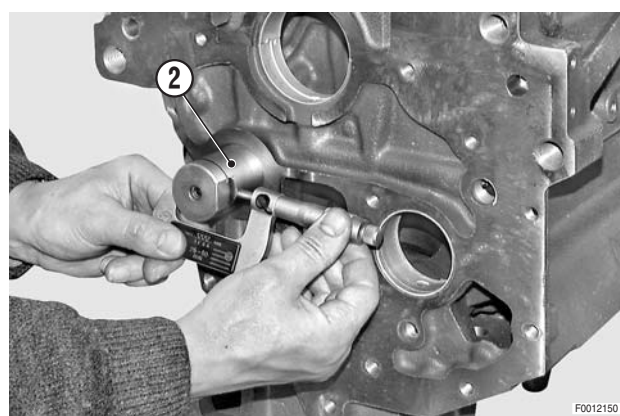
Pos.	Dimensions	Normal measurement	Maximum tolerance limit	NOTES
1	Camshaft journal	54.970 – 55.000 (2.1658 – 2.1670)	54.950 (2.1650)	
2	Endfloat	0.08 – 0.206 (0.0032 – 0.0081)	Max. 0.25 (Max. 0.001)	

## 16.8 TIMING GEARS

- 1 - Using a bore gauge, measure the inside diameter of the bush of the intermediate timing gear (1).  
If the wear exceeds the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS», renew the bush.



- 2 - Using a micrometer, measure the diameter of the shaft (2) for the intermediate timing gear.  
If the diameter is less than that specified in «TECHNICAL DATA AND DIMENSIONS», renew the shaft.
  - ★ The shaft must certainly be renewed if it shows any sign of seizure.
  - ★ For removal and refitting, see «TECHNICAL DATA AND DIMENSIONS».



- 3 - Before timing the valves, check the backlash between the timing gears in order to prevent excessive noise in service.
  - ★ Permitted backlash:  
0.06 – 0.1 mm (0.0024 – 0.0004 in.)  
The correct backlash can be restored by choosing the appropriate size intermediate timing gear from the three available. The gears are identified by coloured labels:

⚠ For the checking procedure, see «ENGINE ASSEMBLY - Valve timing».

Unit of measurement: mm (in.)

Measured backlash	Gear to fit	NOTES
0.06 – 0.10 (0.0024 – 0.004)	Red label	Standard gear
0.11 – 0.13 (0.0043 – 0.005)	Yellow/white label	1st oversize *
over 0.13 (over 0.005)	Green label	2nd oversize *

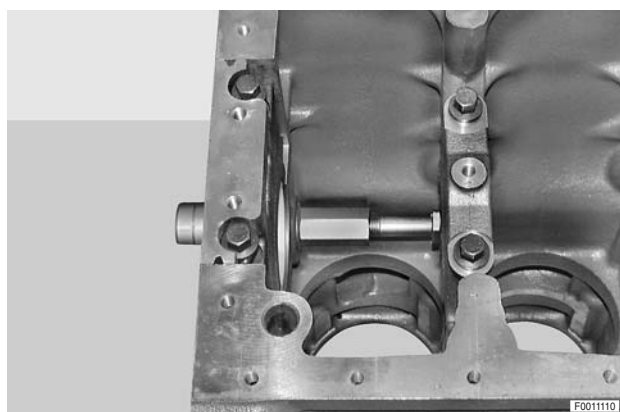
\* Oversizes have increased tooth thickness on the pitch diameter.

### 16.8.1 Removal of the gear shaft

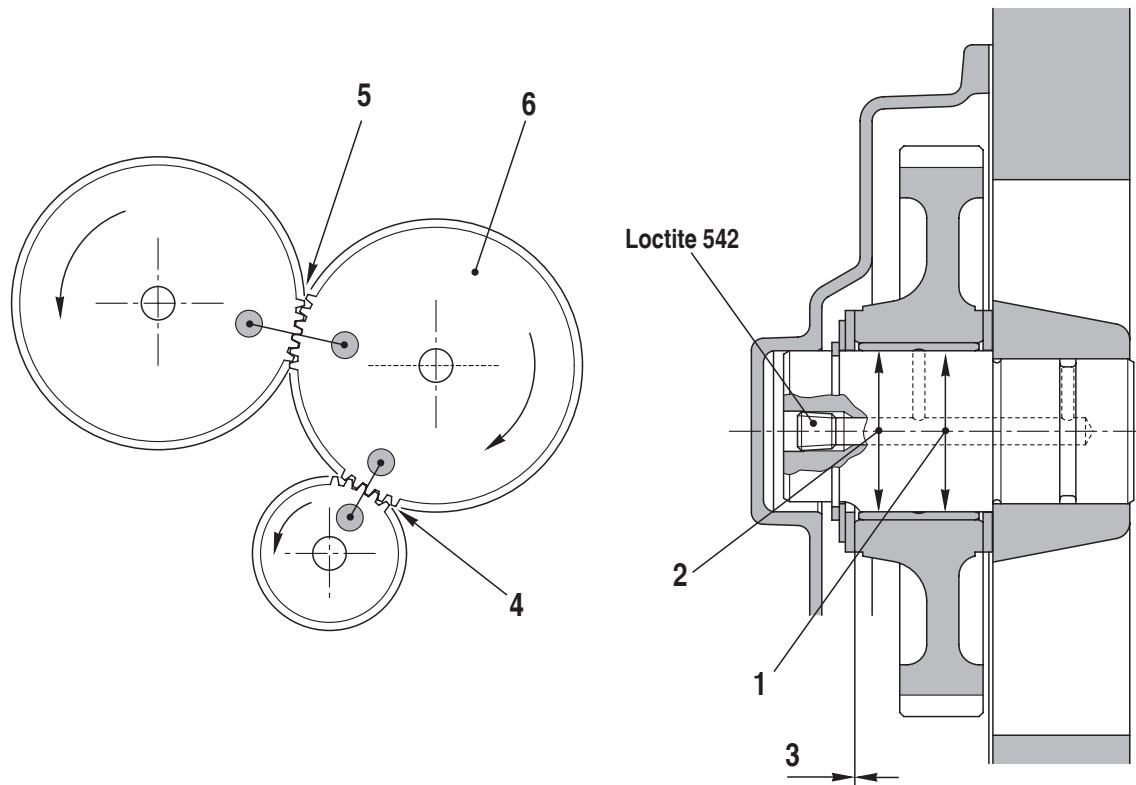
- 1 - To remove the shaft, use a bolt with a long nut between the shaft and inner bulkhead.
- 2 - Before fitting the new gear shaft, carefully clean the oil hole; after fitting shaft to the engine block, close the oil hole with the plug coated with sealant.

🔧 Plug: Loctite 242

- 3 - The gear shaft **must only** be fitted to the engine block using the liquid nitrogen cooling method.
  - ★ DO NOT use a hammer, mallet or hydraulic installer.



## TIMING GEARS



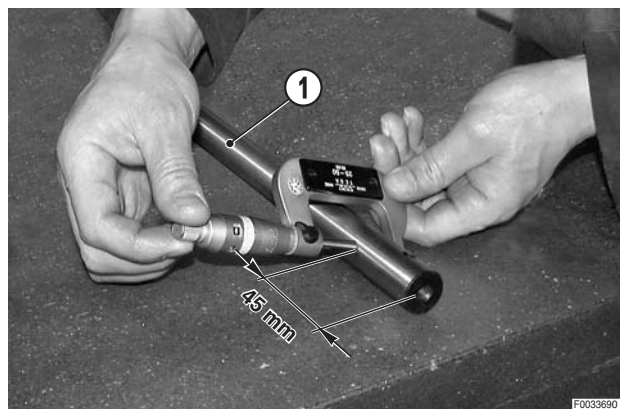
D0001170

Unit of measurement: mm (in.)

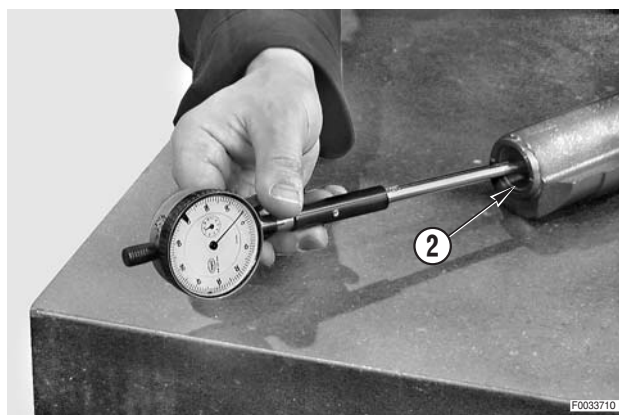
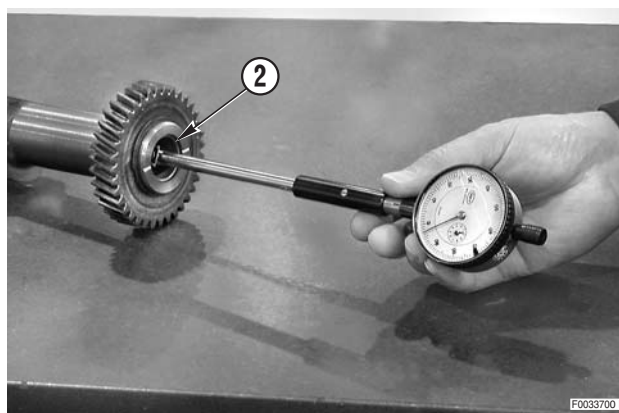
Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Inside diameter of intermediate timing gear bush	40.025 (1.5770) 40.064 (1.5785)	40.125 (1.581)	
2	Outside diameter of intermediate timing gear shaft	39.975 (1.5750) 40.000 (1.5760)	39.950 (1.574)	
3	Intermediate timing gear endfloat	0.13 – 0.53 (0.0051 – 0.0208)	Max. 0.80 (Max. 0.0315)	
4	Backlash between crankshaft timing gear - intermediate timing gear	0.06–0.10 (0.0024 – 0.004)	Max. 0.10 (Max. 0.004)	
5	Backlash between intermediate timing gear and camshaft timing gear	0.06–0.10 (0.0024 – 0.004)	Max. 0.10 (Max. 0.004)	
6	Standard	Red label	for backlash 0.06–0.10 (0.0024 – 0.0004 in.)	
	1st oversize	White/yellow label	for backlash 0.11–0.13 (0.0043 – 0.005 in.)	
	2nd oversize	Green label	for backlash greater than 0.13 (0.005 in.)	

**16.9 HARMONIC BALANCER (For 4 cylinder engines only)**

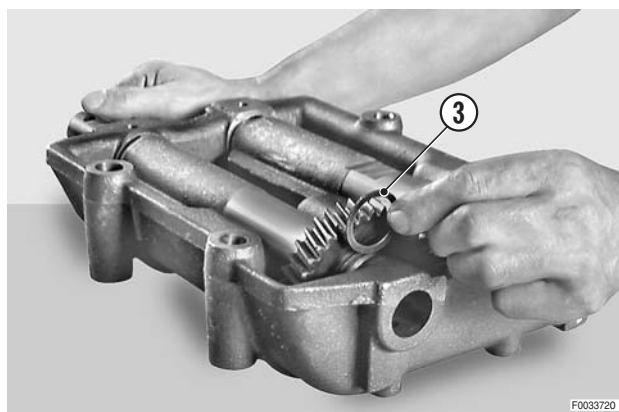
- 1 - Using a micrometer, check the diameter of the shafts (1) in the area in which the bob weight bushes rotate. If the diameters are less than the limits specified in «TECHNICAL DATA», replace the shafts.



- 2 - Using an inside micrometer, check the diameter of the bushes (2) of the bob weights. If the wear exceeds the permitted maximum indicated in «TECHNICAL DATA», renew the bushes.

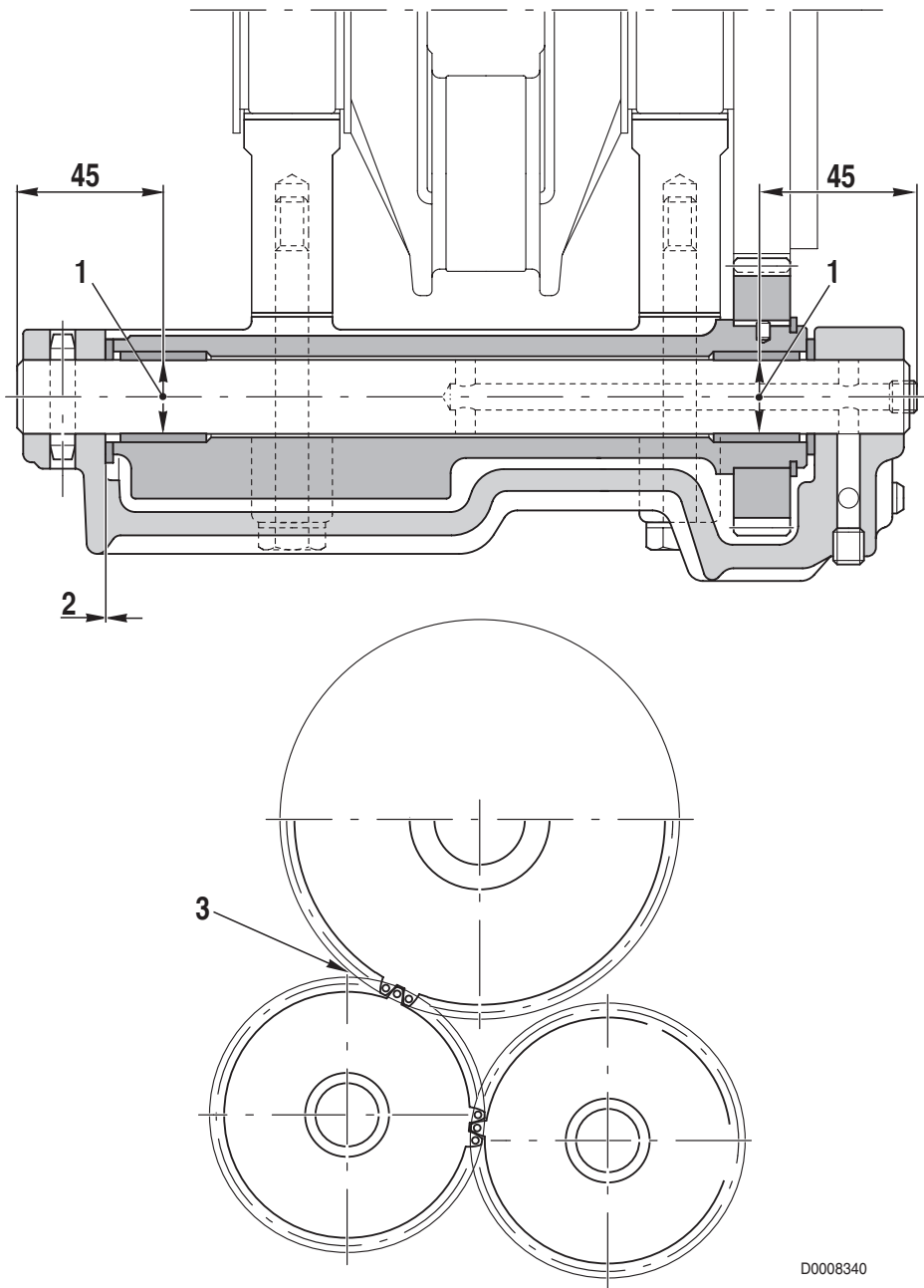


- 3 - After assembly of the weights and before fixing the shafts, check that the end float of the weights is within the tolerance limits specified in «TECHNICAL DATA». If the end float is greater, replace the thrust washes (3).





HARMONIC BALANCER



D0008340

Unit of measurement: mm (in.)

Pos.	Dimensions	Normal measurement	Tolerance limit	NOTES
1	Bushes inside diameter	$26^{+0.050}_{+0.075}$	26.150	
	Shafts outside diameter (45 mm)	$26^{0}_{-0.013}$	–	
2	Weight end float	0.10–0.43	–	
3	Gear tooth backlash	0.10–0.20	0.20	

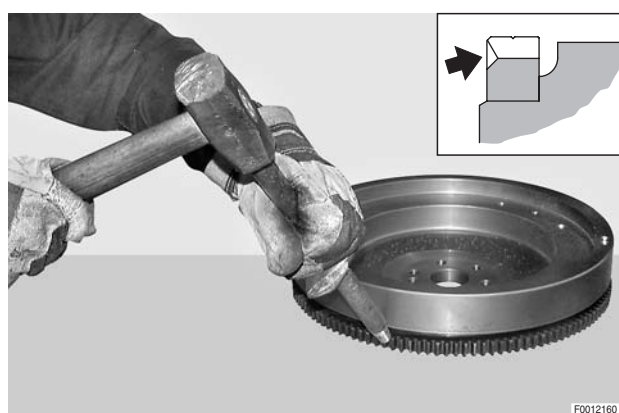
## 16.10 FLYWHEEL

The flywheel is to be checked as follows:

- a - Check the condition of the ring gear (visual examination).
- b - Check radial runout (after fitting).
- c - Check flywheel face runout (after fitting)

- 1 - If the ring gear is damaged, it must be removed using a drift.

- ★ Tap the ring gear evenly around the circumference until it comes free of the flywheel.
- ★ Note which way round it is fitted; the chamfered side of the teeth should be oriented away from the engine block.

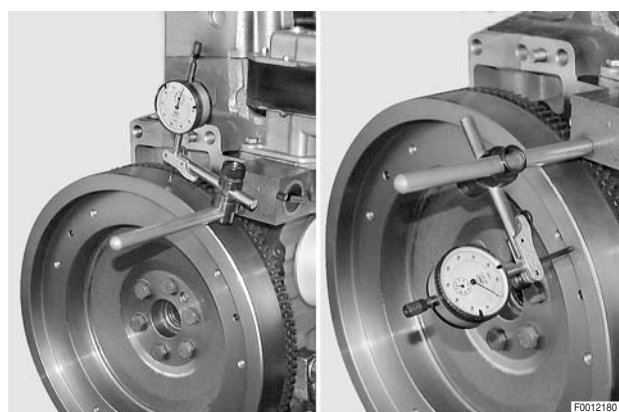


- 2 - Clean the ring gear carefully; heat the new ring gear on a thermostatic hotplate to approx. 100°C and then fit it to the flywheel; make sure that it is fully inserted on its seat.



- 3 - After having fitted the flywheel to the crankshaft and tightened down the retaining bolts, use a dial gauge to check the radial and face runout.

- ★ The maximum permissible runout is 0.10 mm (0.004 in.).
- ★ For the tightening torque, see «ENGINE ASSEMBLY».



## ENGINE ASSEMBLY


- 1 - All engine assembly operations must be carried out on a clean bench in a clean environment.
- 2 - Before proceeding with assembly, remove all carbon deposits, old sealant, etc.. from the parts to be re-used; clean out the oil ways with compressed air.
- 3 - Lightly lubricate all parts with engine oil prior to assembly, except for the bolts unless otherwise indicated.


**!** This rule does not apply to the cylinder liners and the relative O-rings and seal seats; the cylinder liners are to be inserted into the block dry and in accordance with the specific assembly instructions.

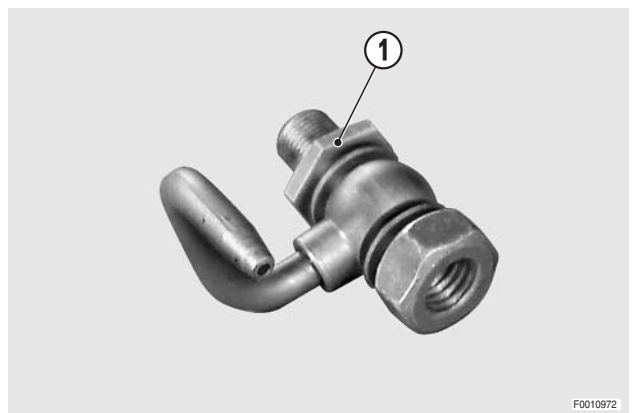
- 4 - When positioning the bearing shells of the main bearings, big-end bearings and camshaft bearings make sure that oil holes are correctly oriented.
- 5 - Always remove excess sealant.

### 17. FITTING THE PISTON COOLING NOZZLES

- 1 - **Only if the sprayer nozzles have been removed.** Apply sealant to the root of threaded fitting (1), screw into the block and tighten.

 Fittings: Loctite 242

 Fittings:  $30 \pm 5$  Nm ( $22.1 \pm 3.7$  lb.ft.)




- 2 - Rotate the engine block and apply the special engine overhaul tool to cylinder n. 1; fit in the order given: the first copper gasket (2), the oil jet (3), the second gasket (4) and then the nut (5).

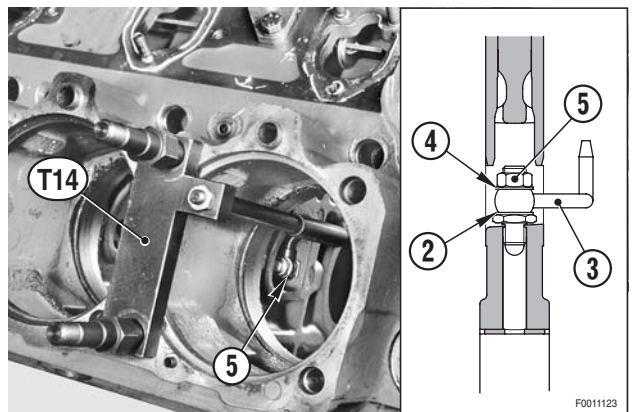
With the jet inserted in tool **T14**, tighten the nut (5).

For pistons without oil way:  
tool (code 5.9030.731.4)

For pistons with oil way:  
tool (code 5.9030.732.4)

 Nut:  $25 \pm 4$  Nm ( $18.4 \pm 2.9$  lb.ft.)

- 3 - Repeat the operation for the remaining cylinders.



F0010972

F0011123

## 18. FITTING THE CYLINDER LINERS, PISTONS AND CONNECTING RODS

- 1 - Position the O-rings (2) on the cylinder liner (1).  
The O-rings must be perfectly clean and free of grease.

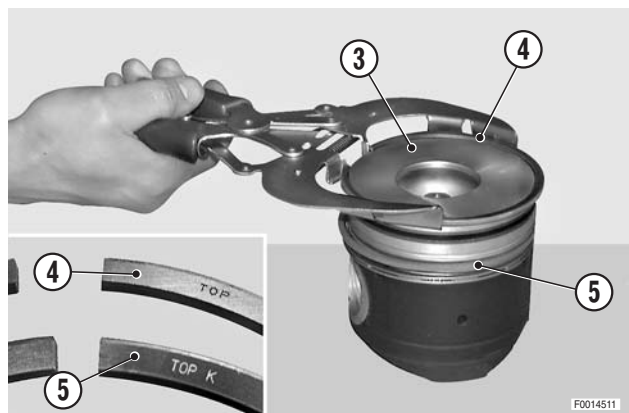
**!** The O-rings have been specially treated and once removed from their packaging, they must not be exposed to the air for more than 48 hours.

★ Do not lubricate the O-rings (2).



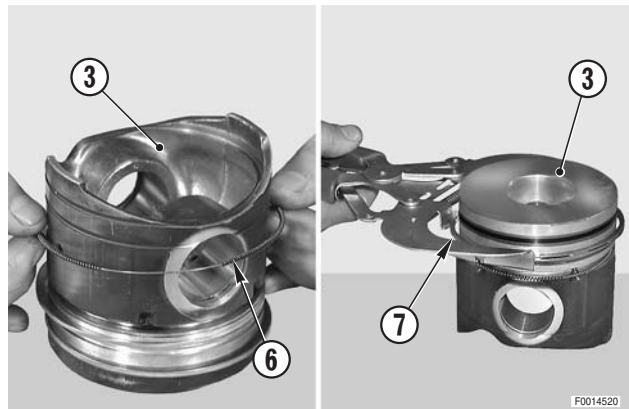
- 2 - Using piston ring pliers, fit the piston rings (4) and (5) to the piston (3).

**!** The second piston ring (5) must be fitted so that the marking TOP is facing the piston crown.



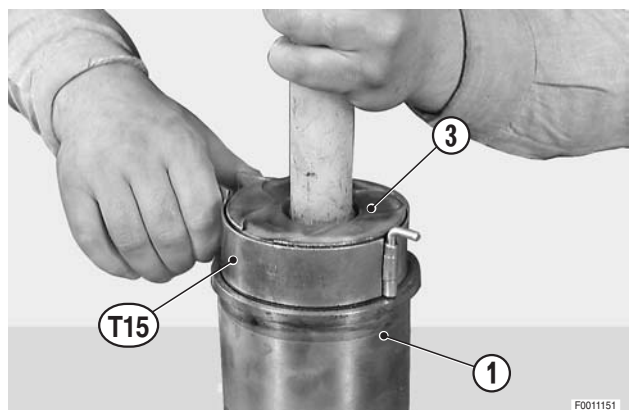
- 3 - Turn over the piston (3) and fit the expander (6) and the oil scraper ring (7).

★ The gap in the oil scraper must be positioned at 180° relative to the gap in the expander.




- 4 - Turn over the cylinder liner (1), lightly oil the bore and partially insert the piston (3).

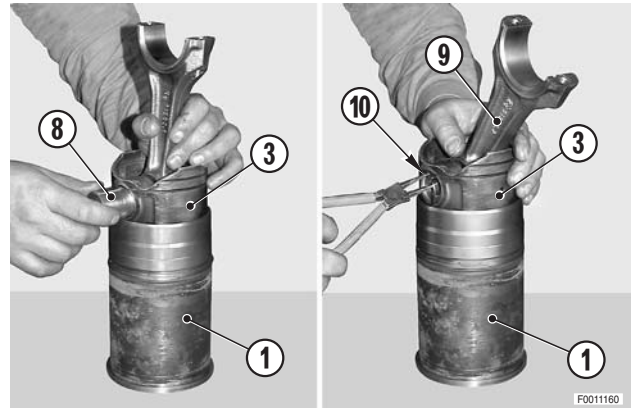
- 5 - Position the piston ring end gaps as indicated in «TECHNICAL DATA AND DIMENSIONS» and, using a piston ring compressor **T15** (code 5.9030.654.0/10) and a drift made of soft material, fully insert the piston (3) in the liner (1).



- 6 - Slide the piston (3) out of the liner so that the bore of gudgeon pin (8) is exposed.

- 7 - Lubricate the gudgeon pin seat (8) and fit the connecting rod (9) and circlips (10).

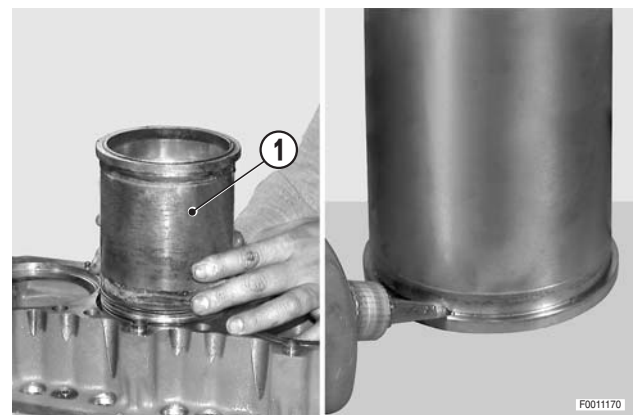
 The connecting rod must be fitted so that the number marking (referring to the big-end cap) is on the opposite side to the arrow marking on the piston.



- 8 - Apply a continuous film of sealant around the flange of the liner (1) and fit the assembly in the corresponding bore of the block.

 Cylinder liner: Loctite 986 AVX

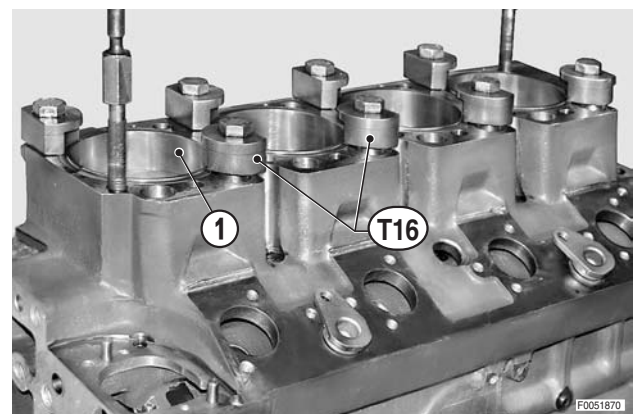
Ensure that sealant film is continuous and avoid contact with the O-rings.



- 9 - Apply constant strong hand pressure **to ensure that the O-rings engage the sealing surfaces** of the block bore.

★ **Do not use** a mallet at this stage.

- 10 - Once the second O-ring has seated in the sealing surface of the bore, drive the liner (1) home using a soft-faced mallet.
- 11 - Fit the **diagonally opposed clamping blocks T16** (code 5.9030.631.4/10) and leave them in position until the sealant has fully cured (approx. 4 hours).

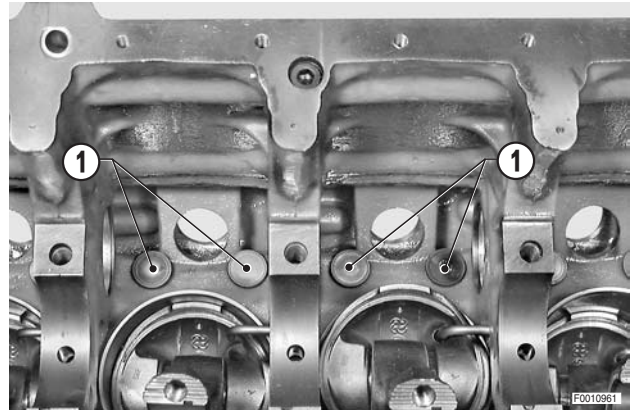





## 19. FITTING THE CAMSHAFT-CRANKSHAFT AND CONNECTING ROD BIG-ENDS

- 1 - Lubricate the seats and fit the cam followers (1).

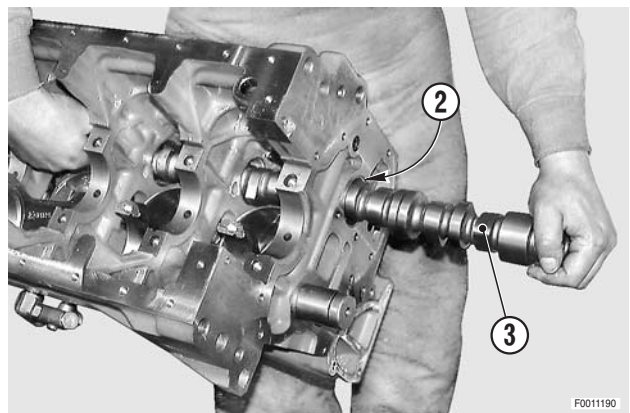
 Cam follower seats: Engine oil



- 2 - Lubricate the bearing shells (2) and install the camshaft (3).

 Camshaft bearing shells: Engine oil

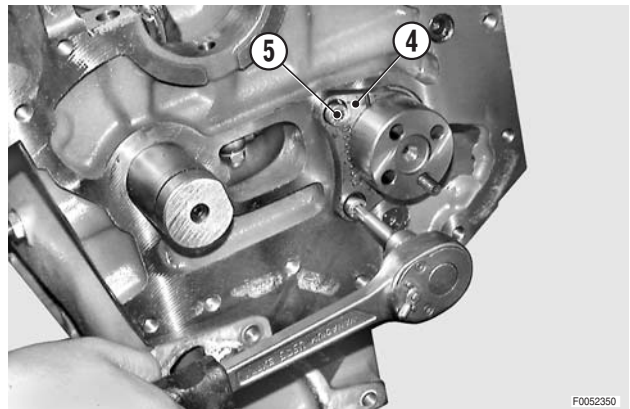
Take great care not to damage the bearings with the cam lobes.



- 3 - Fit the thrust plate (4) and secure it with bolts (5) and washers.

- 4 - Lubricate the camshaft groove that engages the thrust plate and try turning the camshaft. The camshaft should rotate freely without high spots.

★ Check the end float, which must be within the tolerance limits specified in «TECHNICAL DATA AND DIMENSIONS».



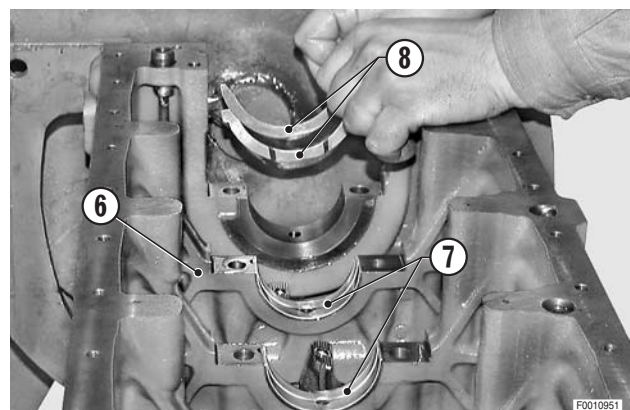
- 5 - Position the main bearing half shells (6) with the oil holes in their seats in the block.

★ Make sure that the tabs of the half shells (7) are located in their notches.


- 6 - Position the two lower semi-circular thrust washers (8).

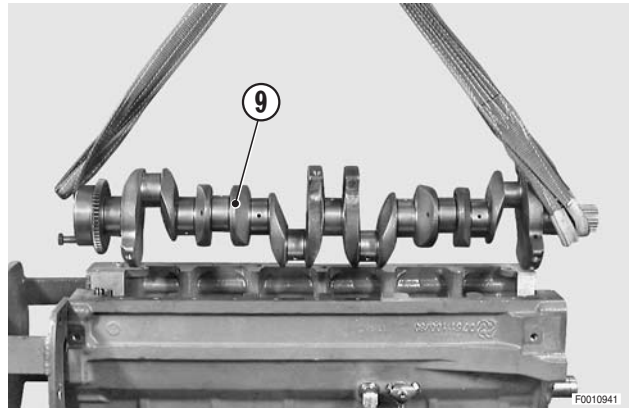
★ The oil grooves must face outwards.

★ To hold the thrust washers in place, coat them in grease.




- 7 - Liberally oil the main bearing shells (7) and the thrust washers (8) and lower the crankshaft (9) into position.

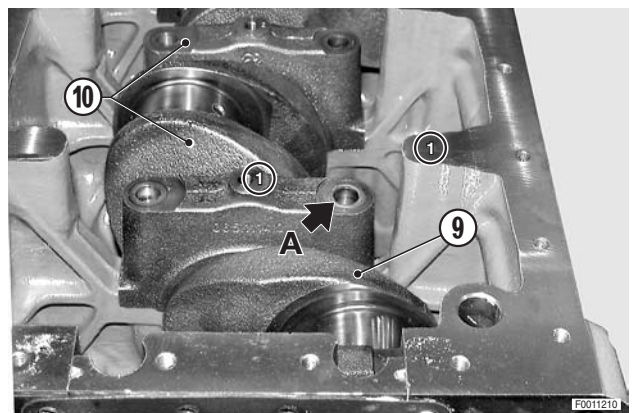
 Bearing shells and thrust washers: Engine oil



- 8 - Liberally oil the crankshaft (9) and fit the main bearing half shells and caps (10).

 Crankshaft: Engine oil

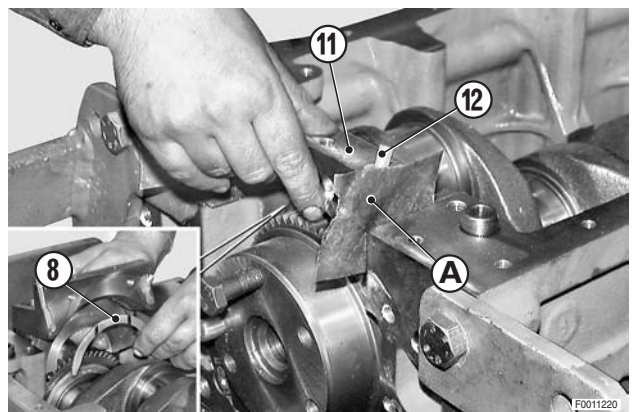
- ★ Make sure that the caps (10) are fitted the right way round; the smaller diameter spot face "A" should be on the injection pump side of the block. The main bearing caps are numbered and must be fitted in the correct sequence in accordance with the numbers marked on the block.



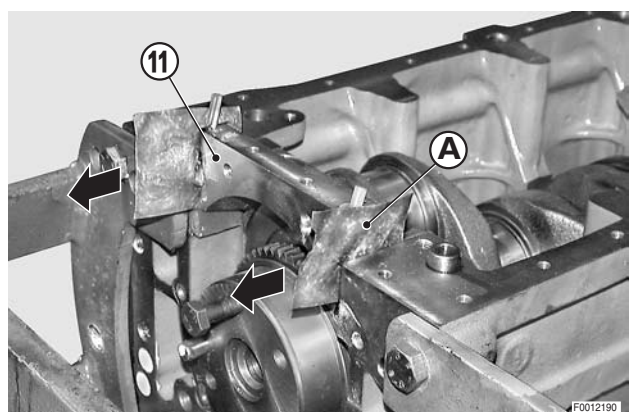
- 9 - Fit the upper semi-circular thrust washers (8) and the triangular seals (12) to the rear main bearing cap (11).

- ★ Apply grease to the thrust washers and seals to stick them in position; also apply grease to the outer surfaces of the seals.

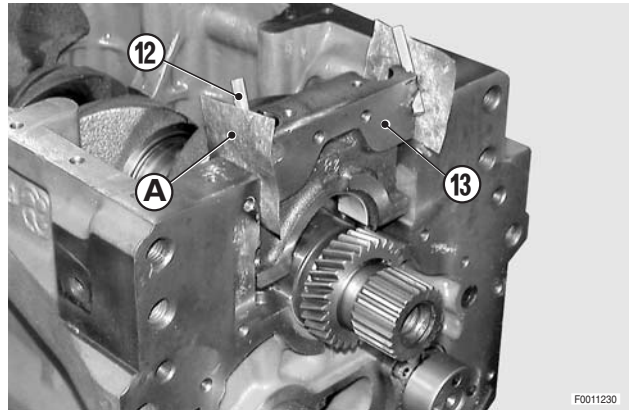
- 10 - Position two guide sheets in soft material "A" (thickness 0.3 mm (0.012 in.)) and fit the rear main bearing cap.




- 11 - Insert the cap bolts and hand tighten to hold the bearing cap (11) in position; withdraw the guide sheets "A" by pulling them in a crosswise direction relative to the seal.




- 12 - Fit the front main bearing cap (13) with the same procedure used for the rear main bearing cap.




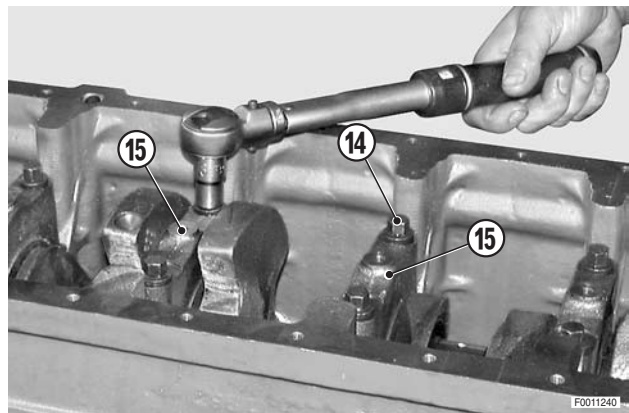
- 13 - With a torque wrench, tighten the five cap bolts (14) to the Stage 1 torque setting.

 Bolts: Stage 1 = 10 Nm (7.4 lb.ft.)

- 14 - Still with the torque wrench, tighten the main bearing cap bolts to the Stage 2 torque setting.

 Bolts - Stage 2: 40 Nm (29.5 lb.ft.)

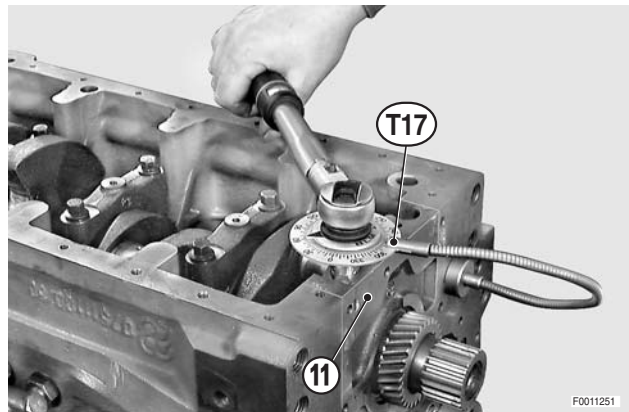
 Before proceeding, check that the crankshaft endfloat is within the tolerance limit specified in «TECHNICAL DATA AND DIMENSIONS» (For endfloat checking procedure, see «13.3 REMOVAL OF THE CRANKSHAFT»).



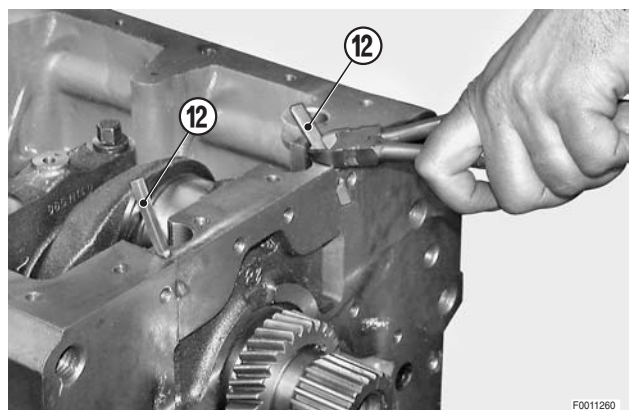
- 15 - Using the same torque wrench and a protractor for angle-tightening **T17** (code 5.9030.640.0), tighten the main bearing cap bolts (11) and (13).

 Bolts: Angle-tighten an additional  $55^{\circ} \pm 1^{\circ}$

- 16 - Check that the crankshaft rotates freely without high spots.



- 17 - Trim off the protruding parts of the triangular seals (12).  
Make sure that the seal protrusion does not exceed 0.2 mm (0.008 in.).





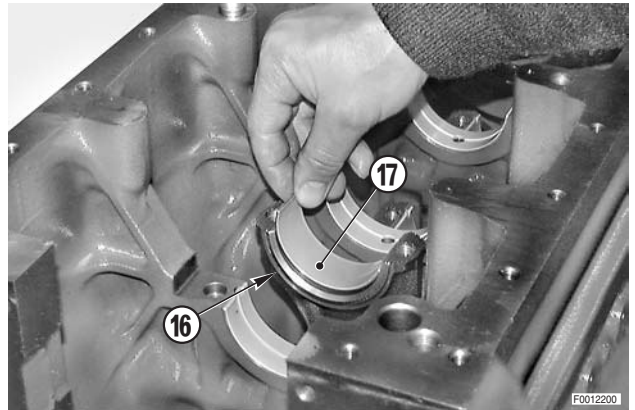
- 18 - Fit the half shells (17) in the big-ends of the connecting rods (16).

★ Make sure that the tabs on the half shells (17) locate in the notches in the big-ends.

- 19 - Liberally oil the half shells and position the big-ends on the crankshaft.

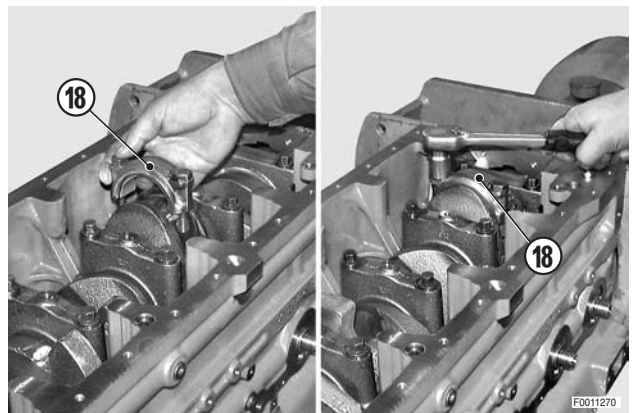
 Half shells: Engine oil.

- ★ Check that the connecting rods are installed the right way round; the number markings should be towards the injection pump side of the engine.



- 20 - Oil the crankshaft, and fit the big-end caps (18) complete with their half shells.

- 21 - Hand tighten the big-end cap bolts (18).

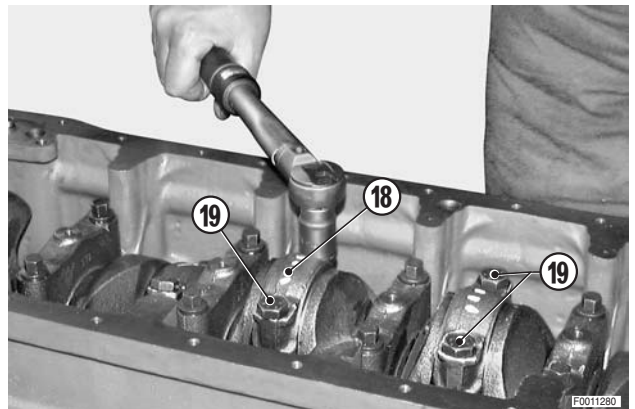


- 22 - Using a torque wrench, tighten the big-end cap bolts (19) to the stage 1 torque.

 Bolts: 10 Nm (7.4 lb.ft.)

- 23 - Still using the torque wrench, tighten the cap bolts (19) to the specified stage 2 torque.

 Bolts stage 2 torque: 30 Nm (22.1 lb.ft.)

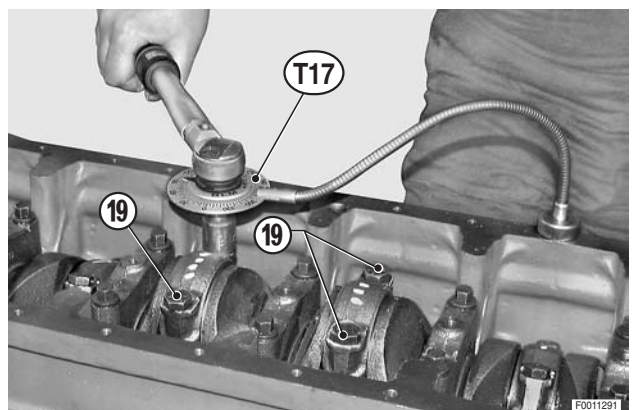


- 24 - Using the same torque wrench and a protractor for angle-tightening **T17** (code 5.9030.640.0), tighten the main bearing cap bolts (19).

 Bolts: Angle-tightening  $90 \pm 1^\circ$

- 25 - Check that the crankshaft rotates smoothly and freely.

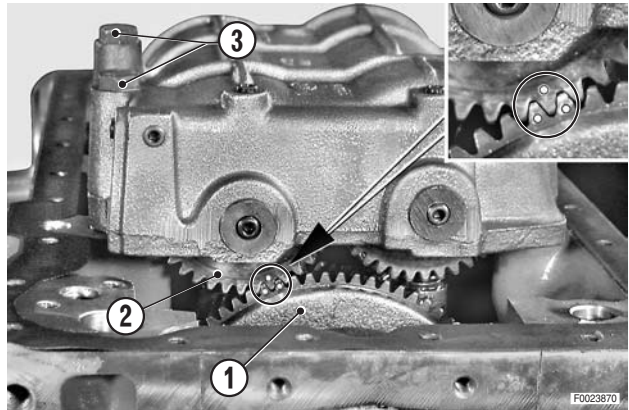
★ While rotating the crankshaft, check that the oil spray is perfectly aligned with the centre of the piston chamber..



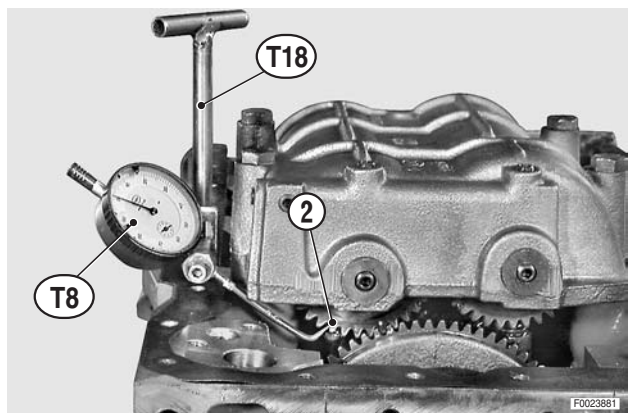
## 20. ASSEMBLY OF THE HARMONIC BALANCER

(For 4-cylinder engines only, only when fitted)

- 1 - Rest the balancer assembly in position, centering the pin of the oil pipe.
- 2 - Lift the assembly from the gear side; rotate the crankshaft (1) and the balancer driving shaft (2) so as to align the reference marks on the respective gears.
- 3 - Secure the assembly with the bolts (3).



- 4 - Position a dial gauge with the contact point **T8** (code 5.9030.888.0) fitted on tool **T18** (code 5.9030.886.0) resting on the side of the driving gear (2) and preload by about 2 mm.



- 5 - Turn the driven gear (4) manually in both directions to check that the gear tooth backlash is as specified in «TECHNICAL DATA».
- 6 - If necessary, add shims between the face of the engine block and the 4 faces of the harmonic balancer (5) to adjust the backlash to within the permitted tolerance limits.
- 7 - Remove the bolts (3) securing the assembly, apply sealant and then tighten to the prescribed torque.

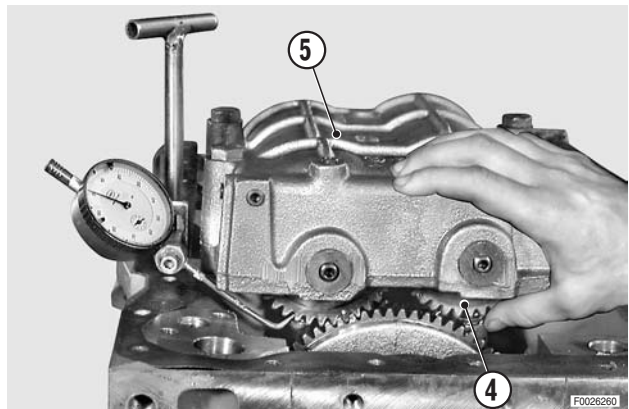


Bolts: Loctite 242



Bolts: 78 Nm (57.5 lb.ft.)

- ★ Tighten the bolts gradually in a crosswise sequence.

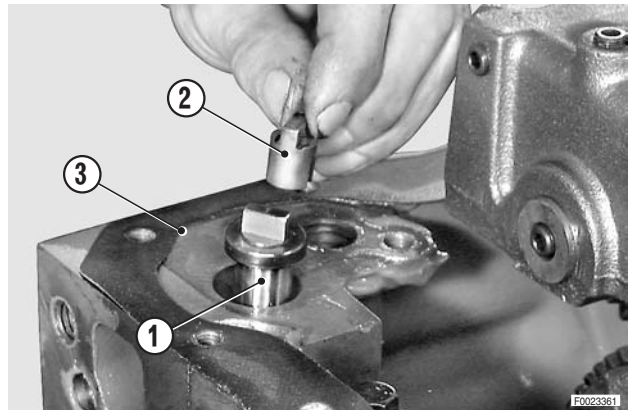




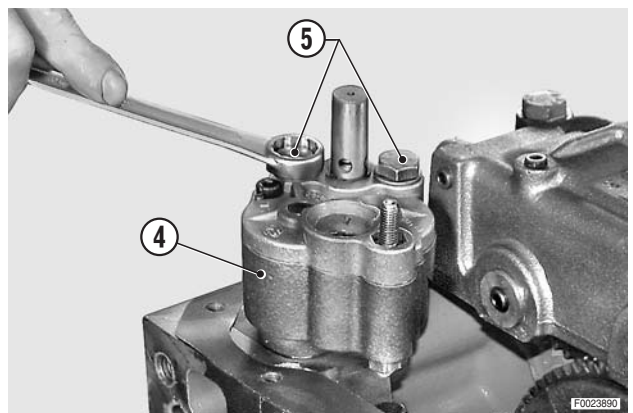
## 21. REFITTING THE OIL PUMP - SUMP PAN

### 21.1 3- AND 4-CYLINDER VERSIONS

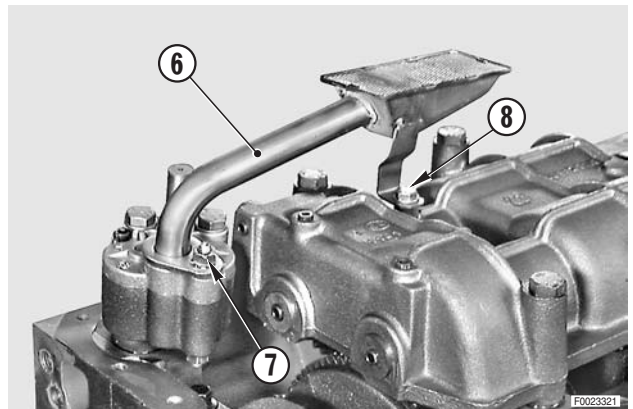
- 1 - Lubricate the pump drive shaft (1) and the drive coupling (2) and fit in the engine block (3).



- 2 - Fit the pump (4) and fix with bolts (5).




- 3 - Fit the suction pipe (6) and fix with nut (7) and bolt (8).

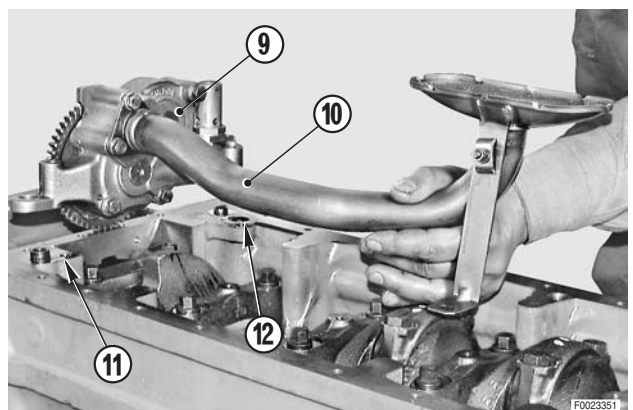


### 21.2 6-CYLINDER VERSION


- 1 - Connect the pick-up pipe (10) complete with O-ring to the oil pump (9) and secure with bolts and washers.

 Bolts: 24 ± 2 Nm (17.7 ± 1.5 lb.ft)

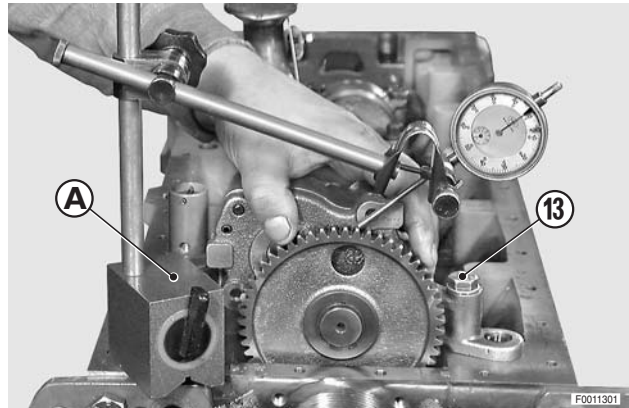
- 2 - Position the shims (11) and (12) that were removed with the pump (9).



- 3 - Secure the pump with the bolts (13) and washers; using a dial gauge with magnetic stand, check the backlash between the drive gears.

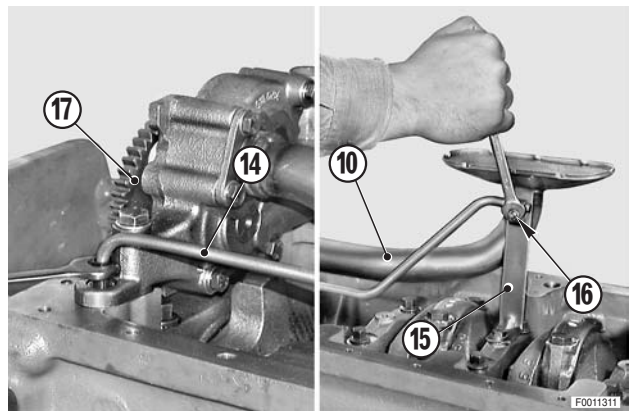
 Bolts:  $49 \pm 5$  Nm ( $36.1 \pm 3.7$  lb.ft.)

- ★ Permitted backlash:  
0.12 – 0.27 mm (0.0047 – 0.0106 in.)
- ★ If necessary, add or remove shims (11) and (12) on both sides.



- 4 - Connect the pump to the return pipe (14) from the oil vapour collector and attach the return pipe to the pick-up pipe (10) with bracket (15) and nut and washer (16). Tighten the connection fitting on the pump.

- 5 - Liberally oil the shaft of the pump drive gear (17).




### 21.3 ASSEMBLY OF THE ENGINE OIL SUMP

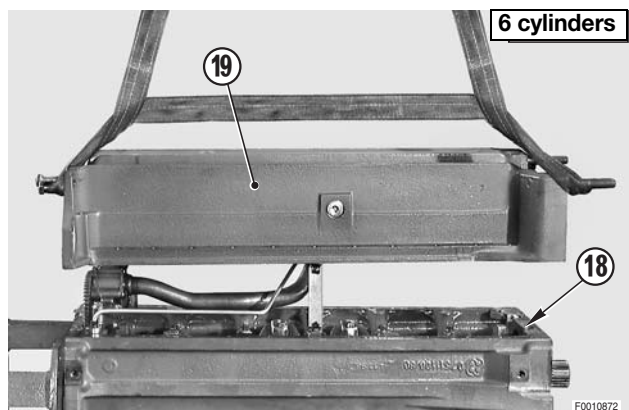
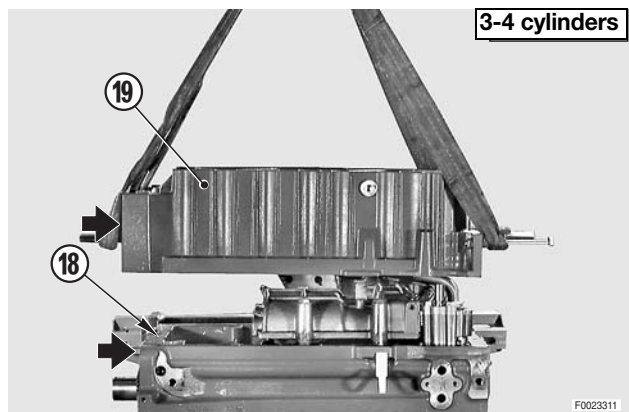
- 1 - Apply sealant to the surfaces in contact with the sump pan in correspondence with the seals of the front and rear main bearing caps.

 Seal area: Silastic 738

- 2 - Position the gasket (18) and fit the sump pan (19) taking care to align the rear face of the sump pan with the rear face of the engine block (shown by the arrows); tighten down the bolts.

- ★ Replace the washers and spacers under the bolt heads in their original positions as noted during dismantling.

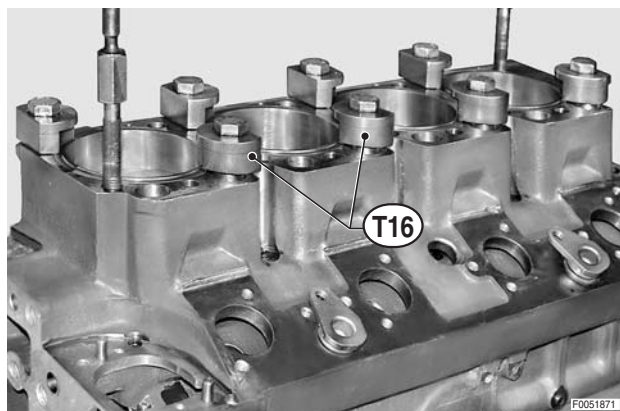
 Bolts:  $30 \pm 5$  Nm ( $22.1 \pm 3.7$  lb.ft.)



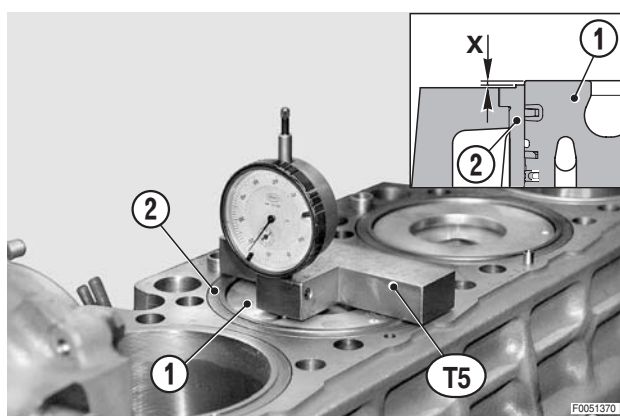
## 22. CALCULATING THE THICKNESSES OF THE HEAD GASKETS AND REFITTING THE CYLINDER HEADS

**!** This operation must be repeated for each cylinder.

- 1 - After the 4 hours required to allow the sealant to cure, remove the clamping blocks **T16** (code 5.9030.631.4/10) fitted during installation of the cylinder liner.
- 2 - Carefully clean all excess sealant from the surfaces.



- 3 - Move the piston (1) of the cylinder in question to TDC, checking the position with tool **T1** (code 5.9030.433.0) and a dial gauge on the piston, applying preload of approximately 4 mm; zeroset the dial gauge at TDC. The tool must be positioned at the centre of the piston parallel to the gudgeon pin.
- 4 - Move the tool and measure the distance "X" between the piston crown (1) and the gasket contact surface on the liner (2).

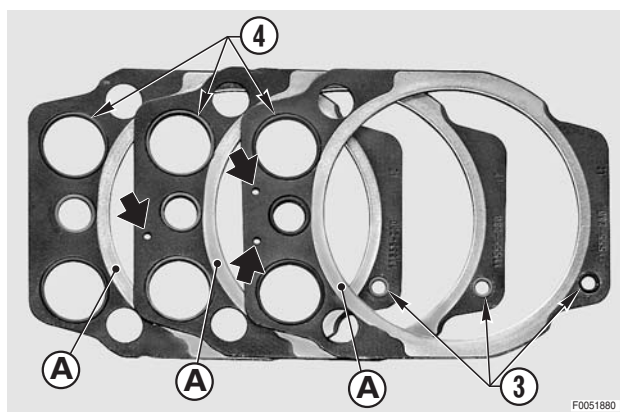


- 5 - 5 - In accordance with the measurement "X", select the correct gasket thickness from the three available.

Distance "X" mm (in.)	Gasket thickness mm (in.)	Gasket colour	N° of holes
0.15–0.40 (0.0059–0.0157)	1.2 (0.0472)	Red	–
0.41–0.60 (0.0161–0.0236)	1.4 (0.0551)	Black	2
0.61–0.80 (0.0240–0.0315)	1.6 (0.0630)	Green	1

- ★ The different gaskets can be identified by the presence or absence of small holes as shown in the figure.
- ★ Position each cylinder gasket, checking that the O-rings (3) are (4) present.  
The gaskets must be fitted the correct way round: check that the gasket code markings "A" and the flame guard ring "B" are facing upwards.

**!** The gaskets must not be degreased.

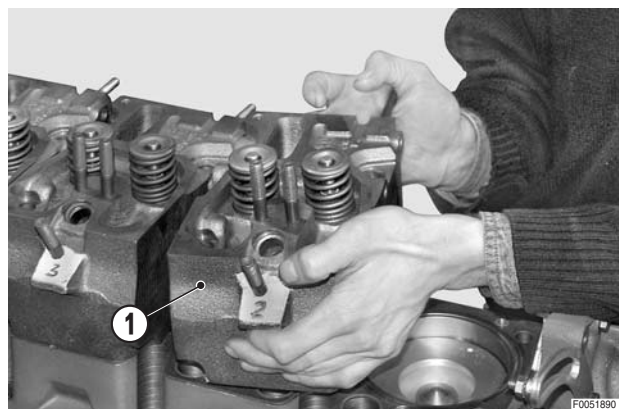





## 23. REFITTING THE CYLINDER HEADS

- 1 - Fit the cylinder heads complete with valves on their respective cylinders.

- ★ Refitting is the reverse of removal.
- ★ Make sure that each head is fitted to the right cylinder.

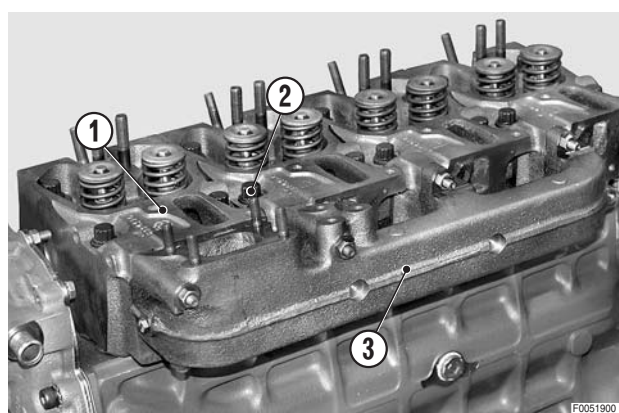


- 2 - Oil the cylinder head bolts (2) and screw them in fully by hand.


 Bolts: Engine oil

- 3 - Check that the mating surfaces are clean and temporarily fit the exhaust manifolds (3); tighten the manifold retaining nuts to a torque of approx. 15 Nm (11 lb.ft.).

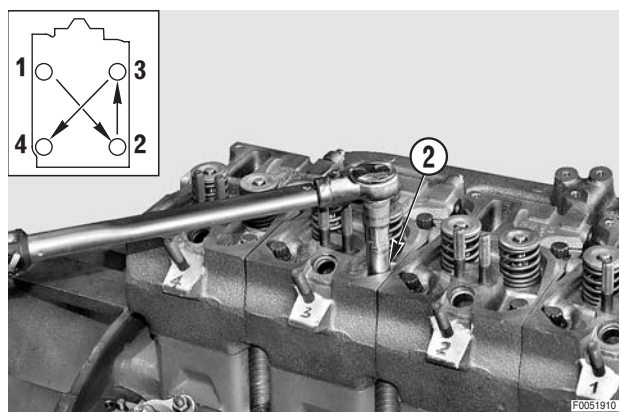
- ★ This operation serves to align the faces of the cylinder head with those of the manifolds: do not fit manifold gaskets at this stage.



- 4 - Using a torque wrench, tighten the bolts (2) to the specified Stage 1 torque setting.

 Bolts Stage 1 torque: 50 Nm (37 lb.ft.)

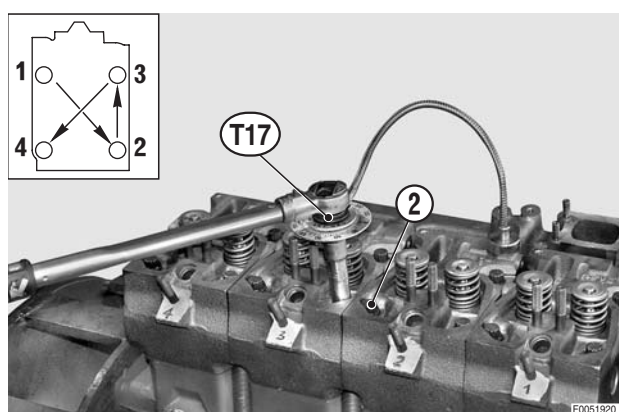
- ★ Tighten the bolts in the sequence indicated.



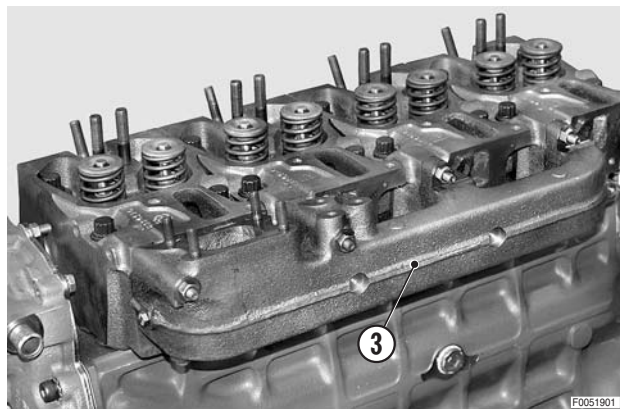
- 5 - Using the same torque wrench and a protractor, perform the final angle-tightening **T17** (cod. 5.9030.640.0) of the head bolts (2).

 Bolts: Angle-tightening 100 ±3°

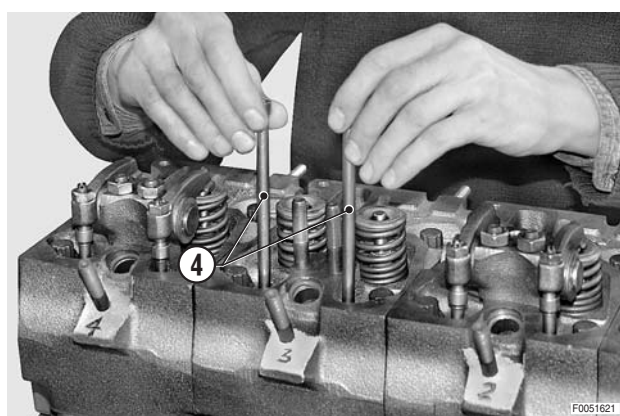
- ★ Tighten the bolts in the sequence indicated.



6 - Remove the exhaust manifolds (3).



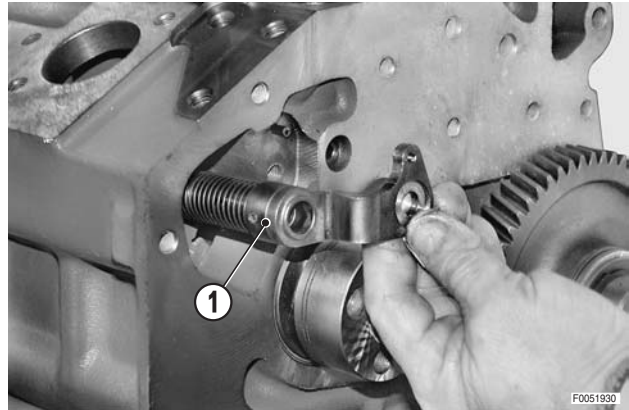
7 - Fit the push-rods (4).






## 24. REFITTING THE INJECTION PUMP CONTROL ROD

- 1 - Install the counter spring assembly (1) for the pump control rod in the crankcase and secure it with the screw.

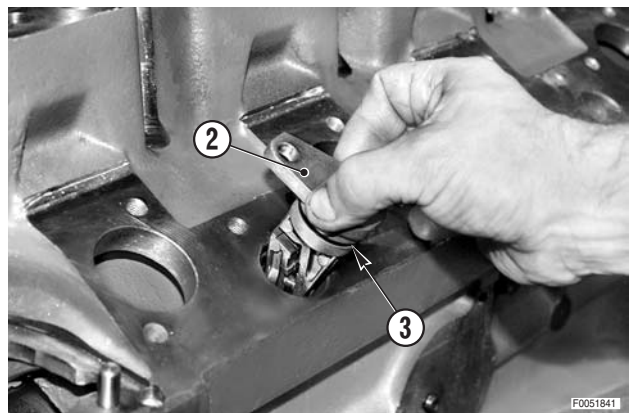


- 2 - Fit O-rings (3) to control rod guides (2).
- 3 - Apply sealant to the cylindrical part below the flange and fit control rod guides (1) and (2), aligning the retaining bolt holes.

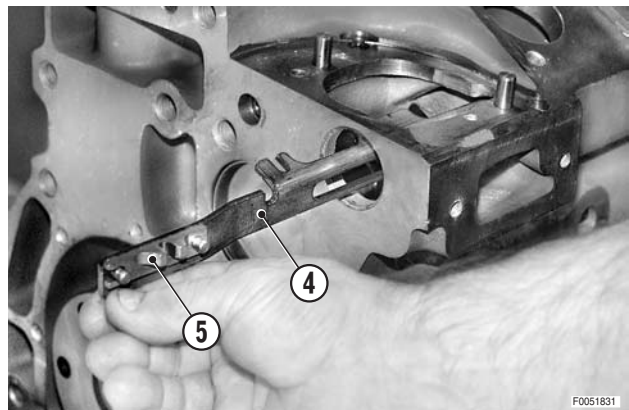
 Control rod guide: Loctite 510

### For 6-cylinder engines only


- ★ The control rod guide without the guide wheel must be fitted in the central position.



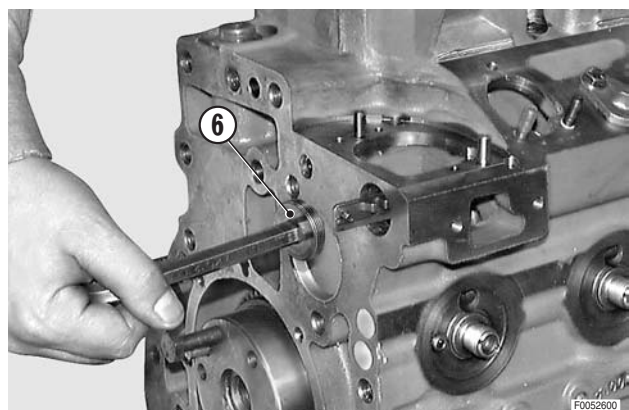
- 4 - Partially screw in the retaining bolts and fit the control rod (4) complete with spring guide, spring and (4) and linkage plate (5).
- ★ To stick the linkage plate (5) in place, apply grease to the surface in contact with the control rod (4).
  - ★ Fix supports (2) and check that the control rod slides freely.



- 5 - Partially screw in the control rod retaining plug (6).
- 6 - Coat the plug (6) with sealant.

 Plug: Loctite 542

- 7 - Screw in the plug (6) far enough to obtain stand-in of 0.5 mm relative to the crankcase surface.




## 25. REFITTING THE MECHANICAL GOVERNOR DRIVE AND THE ELECTRONIC GOVERNOR SUPPORT

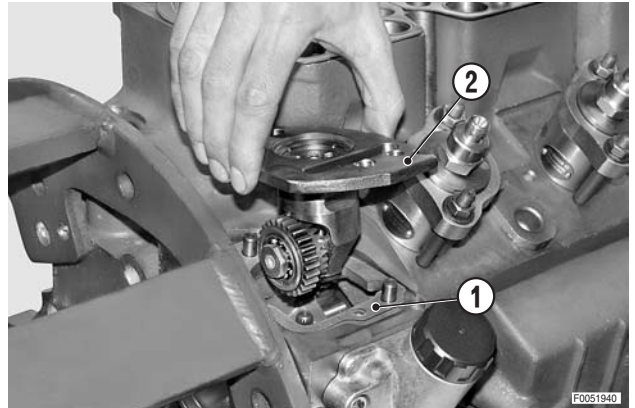
### 3-, 4- and 6-cylinder versions with mechanical governor

#### 3-, 4-cylinder versions with electronic actuator

- 1 - Position the gasket (1) and fit the drive gear (2) centering the oil pump drive shaft (for 3- and 4-cylinder versions) or guide shaft (for 6-cylinder versions).


★ Lubricate the drive gears and the shaft.

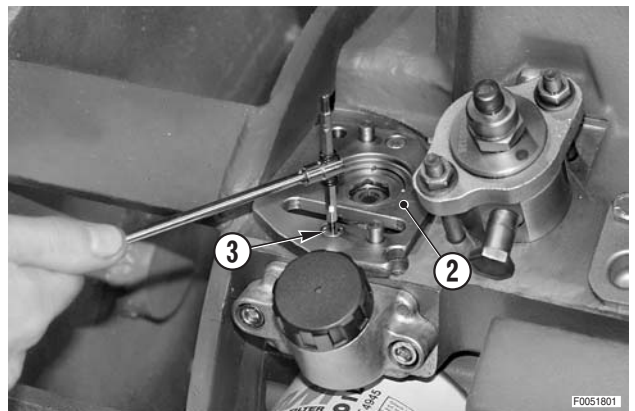
 Gears: engine oil



- 2 - Fix the drive gear (2) with bolts (3).

- 3 - Lubricate the gears and the bearings pouring approx. 30 cm<sup>3</sup> of oil in the flange.

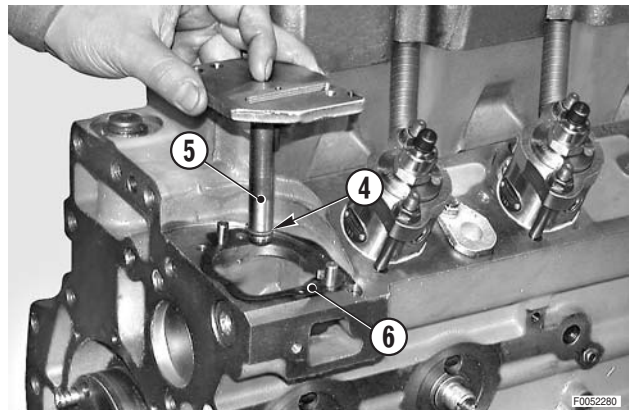
 Gears: engine oil



### 6-cylinder version with electronic actuator

- 4 - Position the gasket (6) and fit the actuator support (5).

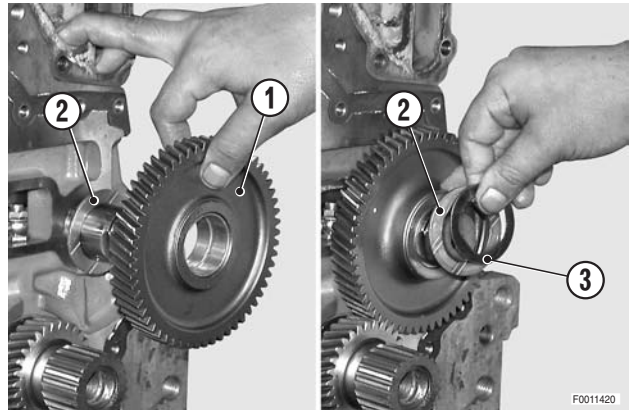
★ Check that the O-ring (4) is present.



## 26. ADJUSTMENT OF THE TIMING GEARS

- ★ Valve timing operations are to be performed on cylinder N° 1.

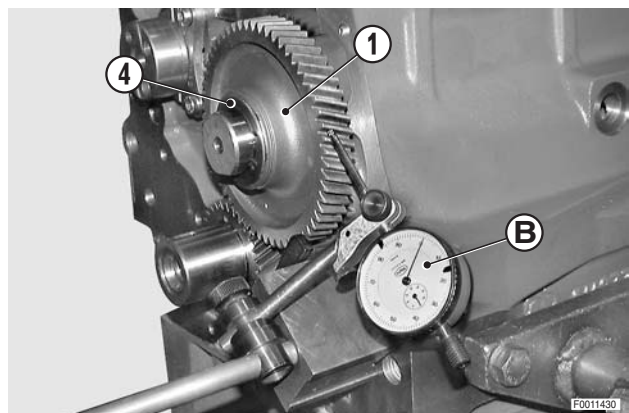
- 1 - Temporarily fit the intermediate timing gear (1) complete with thrust plates (2), shim (3) and circlip (4).



- 2 - Position a dial gauge "B" with magnetic stand so that the contact point is perpendicular to a tooth on the intermediate timing gear; preload the dial gauge by about 2 mm (0.079 in.).

- 3 - Turn the intermediate timing gear (1) in both directions to measure the tooth backlash.

- ★ Make a note of the backlash before proceeding to the next stage.

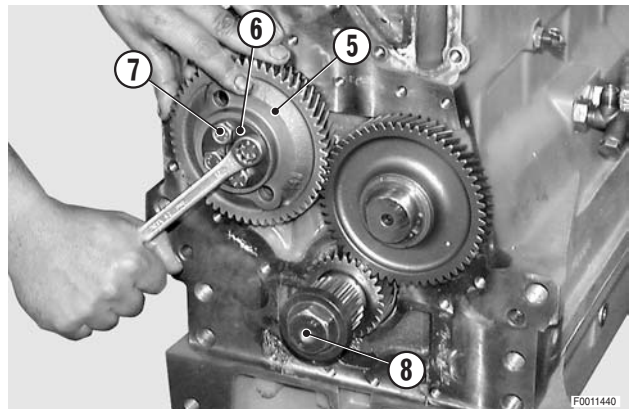


- 4 - Fit the camshaft gear (5), the flange (6) and the new screws (7).

- ★ Tighten the bolts to a low torque 10 Nm (7.4 lb.ft.) to ensure that the gear is forced up against the end face of the camshaft.

- 5 - Screw the pulse wheel retaining bolt (8) fully into the crankshaft.

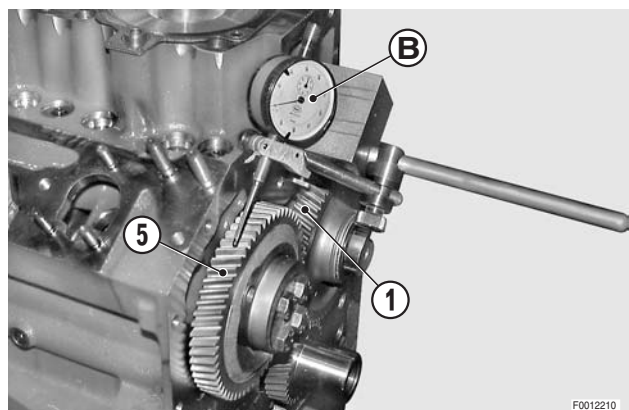
- ★ The bolt will serve as a purchase for the wrench during the subsequent precision checks.



- 6 - Position the dial gauge "B" so that the contact point is perpendicular to a tooth on the camshaft gear.

- 7 - Mesh the intermediate gear (1) turn the camshaft gear (5) in both directions to measure the backlash.

- ★ Make a note of the backlash.




- 8 - Check the two measured backlash values against the tolerance limits indicated in «TECHNICAL DATA AND DIMENSIONS». If the values are not within the tolerance limits, replace the original intermediate timing gear with the appropriate oversize gear to restore optimum backlash.

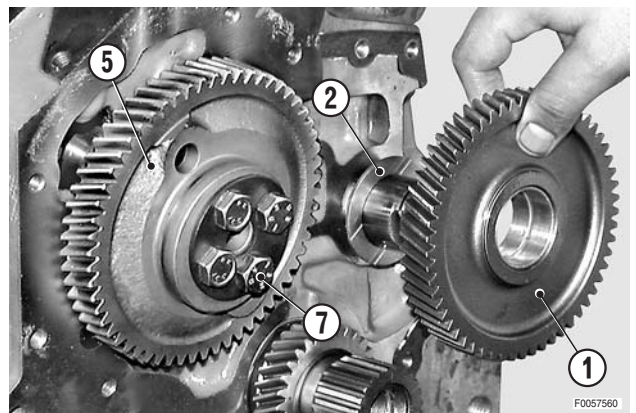
The oversize gears available are indicated in «TECHNICAL DATA AND DIMENSIONS».

- 9 - Remove the intermediate timing gear (1) used for backlash testing, but leave the thrust washer (2) in place.

★ Check that the thrust washer is fitted with the oil grooves facing the gear.

- 10 - Secure the gear (5) by tightening down the screws (7) gradually in a crosswise sequence.

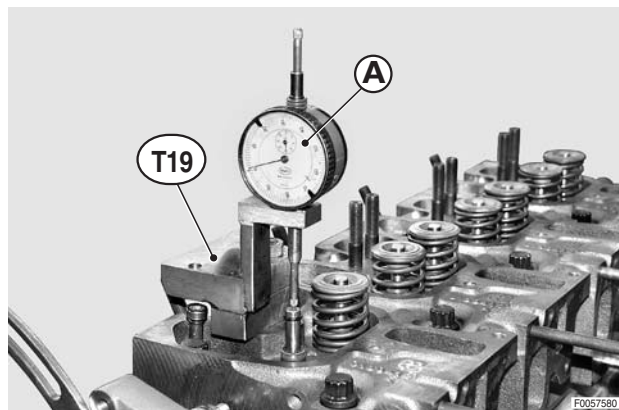
 Screws: 50 ± 4.5 Nm (36.8 ± 3.3 lb.ft.).



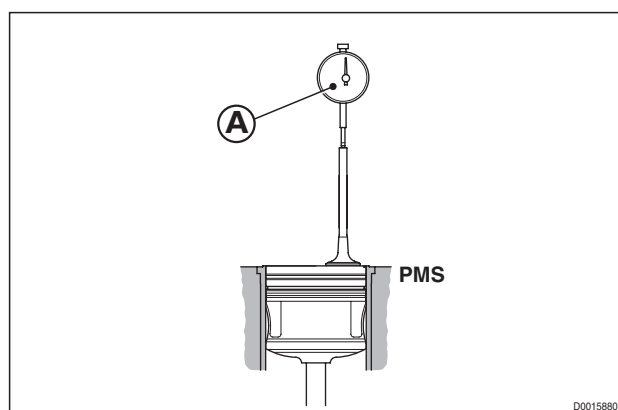


## 27. VALVE TIMING

- 1 - Move cylinder N° 1 to TDC.
- 2 - Remove the spring of the inlet valve and seal ring.
  - ★ After removing the spring, fit an O-ring to the end of the valve stem to prevent the valve from accidentally falling into the cylinder.
- 3 - On the two studs for inlet valve rocker support, fit tool **T19** (code 5.9030.615.0) complete with the dial gauge **"A"**.
  - ★ The dial gauge **"A"** used for the inlet valve must have a stroke of 25 mm (0.985 in.).

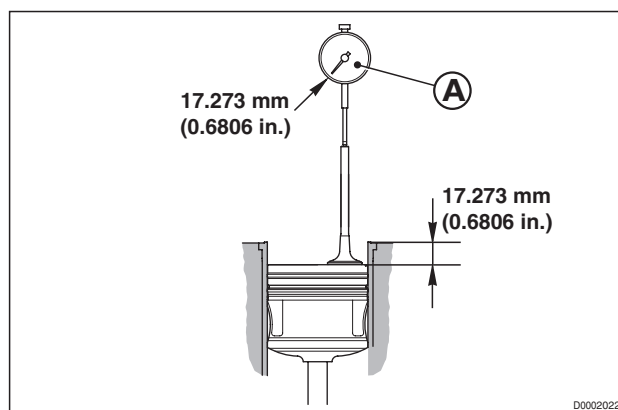


- 4 - Preload the dial gauge **"A"** on the inlet valve by about 20 mm (0.788 in.), find TDC and set the gauge to zero.

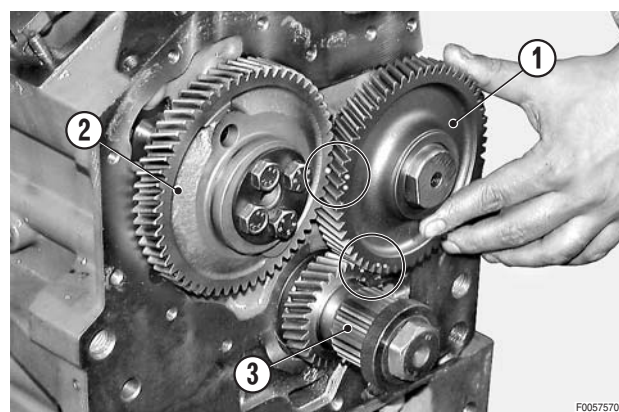


- 5 - Turn the crankshaft clockwise until the piston has performed a downstroke of exactly 17.273 mm (0.6806 in.).

**!** The specified stroke position must be obtained through clockwise rotation only. If the downstroke continues past this position, return the piston to TDC and repeat the entire operation.



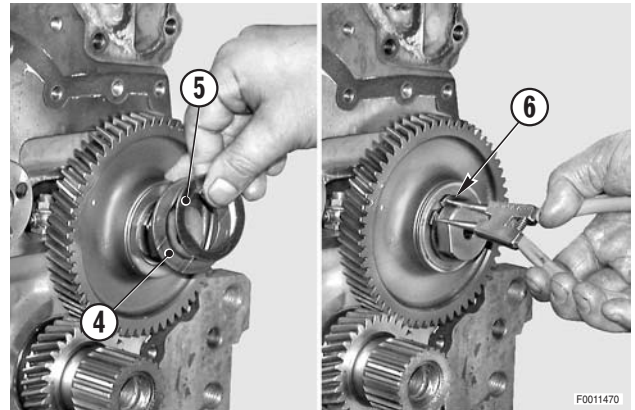
- 6 - Fit the intermediate gear (1), aligning the timing marks on the camshaft gear (2) and the crankshaft gear (3).





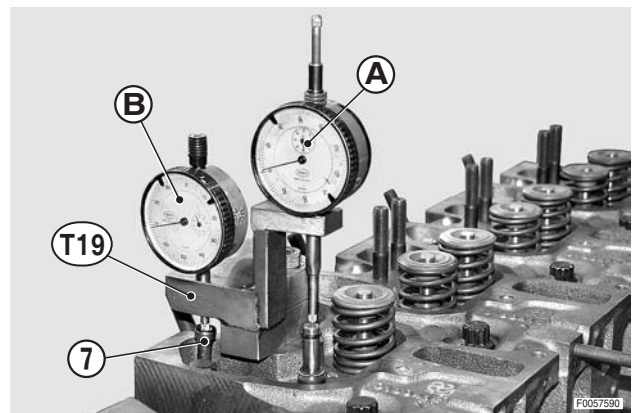
- 7 - Fit the bronze thrust washer (4), the shim (5) and the circlip (6).

★ Check that oil grooves on the thrust washer (4) are facing the intermediate timing gear.



### 27.1 Checking the camshaft timing

- 1 - Fit dial gauge "B" on the tool **T19** (code 5.9030.615.0) and position it on the pushrod (7).
- 2 - Rotate the crankshaft clockwise, to bring the valves over cylinder N° 1 to the "on the rock" position.
- 3 - Continue with the clockwise rotation of the crankshaft until the piston has performed a downstroke of 17.23 mm (0.6789 in.), as shown on the dial gauge "A".
- 4 - Preload the dial gauge "B" by approx. 5 mm (0.197 in.).  
3 - In this condition, zeroset the dial gauge positioned on the pushrod (7).
- 5 - 4 - Rotate the crankshaft counter-clockwise and check on the dial gauge "B" that the pushrod performs a downstroke of  $3.93 \pm 0.05$  mm ( $0.0.1548 \pm 0.002$  in) to arrive at the valve closed period of the cam.



## 28. TIMING THE INJECTION PUMPS

**!** 1 - The operations described below refer to cylinder N° 1, but they must be repeated for all the cylinders.

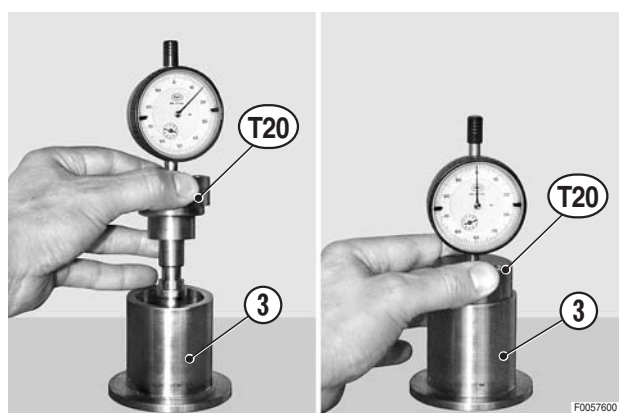
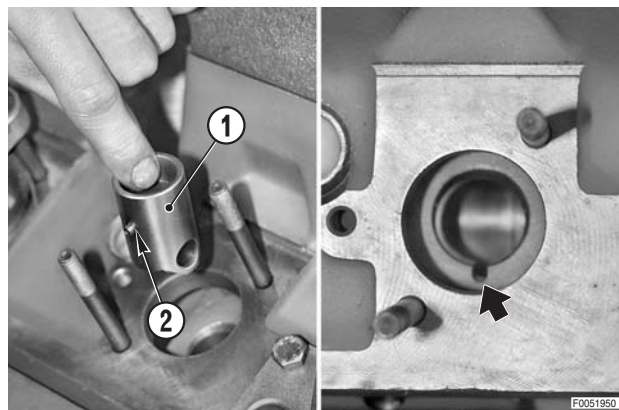
2 - These operations must be carried out each time a new camshaft is fitted and whenever the valve timing is adjusted, whenever a new pump control rod or cam follower roller is fitted.

1 - Lubricate externally and install all the injection pump roller assemblies (1) in the crankcase.

 Roller assemblies: engine oil

★ Make sure that the pins (2) are engaged in their seats and the rollers (1) are in contact with the cams.

2 - Zeroset the dial gauge stand **T20** (code 5.9030.950.0) in the sleeve (3) (code 5.9030.958.0).

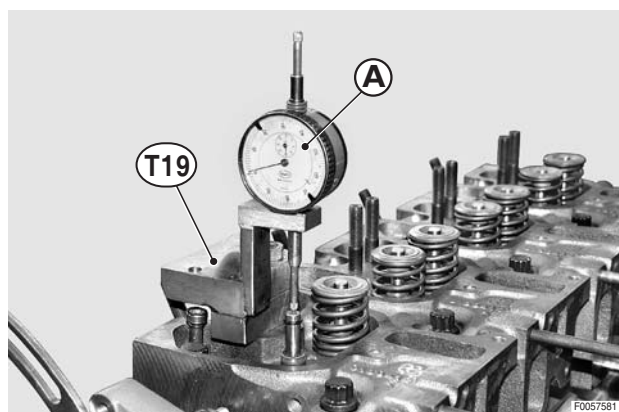


3 - Bring the piston in cylinder N° 1 to TDC at the beginning of its power stroke and zeroset the dial gauge "B".

4 - Turn the crankshaft counter-clockwise so that the piston moves down by about 5 - 6 mm.

5 - Slowly turn the crankshaft clockwise to take up the play and bring the piston to the downstroke position of:

Downstroke mm (in.)	Static advance angle
1.94 (0.0764)	13°
2.92 (0.115)	16°



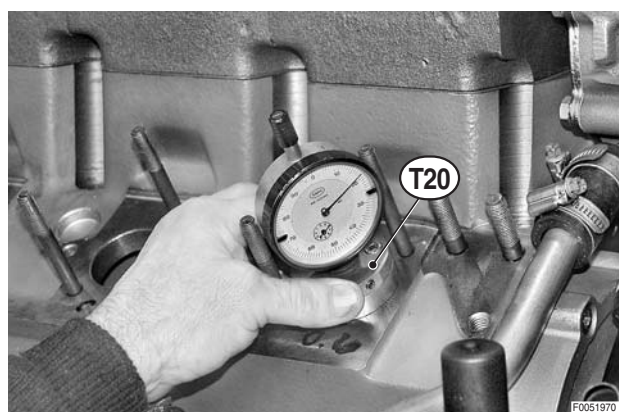
6 - Install tool **T20** (code 5.9030.950.0) in the pump seating and push it fully down.

7 - Measure the difference "S" relative to the zeroset operation in stage 2 (Example S=0.58 mm (0.0228 in.)).

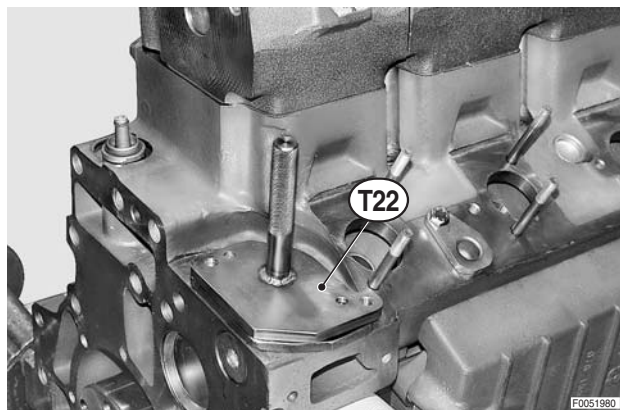
★ Take the readings for all the pumps.

★ Round off the value "S" to the nearest tenth of a millimetre.

Example: 0.58 mm → 0.60



- 8 - Fit the control rod alignment tool **T22** (part no. 5.9030.960.0 for mechanical regulator – part no. 5.9030.959.0 for electronic regulator) and lock it in place.

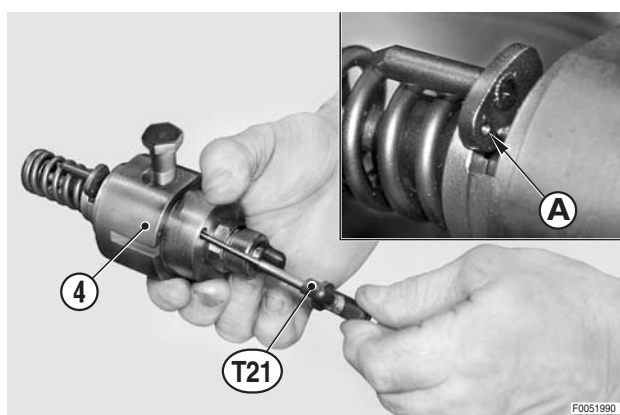


- ⚠ Leave the plugs on the pump fittings and the pipe unions in place until reconnection of the delivery, supply and return pipes.

- 9 - Remove the rubber plug from the injection pump (4) and insert the control lever locking pin **T21** (cod. 5.9030.951.0).


- ⚠ The tapered end of the pin **T21** (code 5.9030.951.0) must be aligned with and forced into the seating **"A"** on the pump control lever.

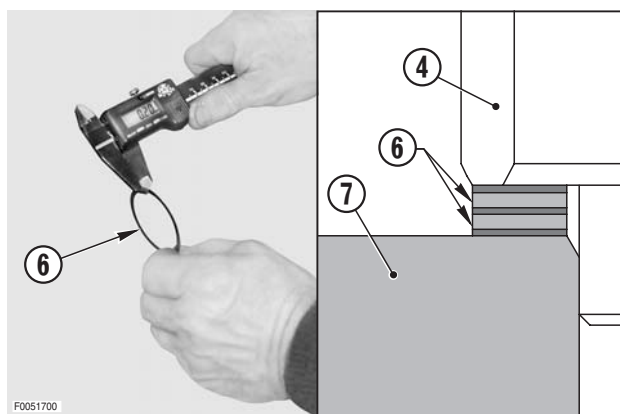
- ★ To hold the position, rotate the handle **CLOCKWISE** to engage the collar.



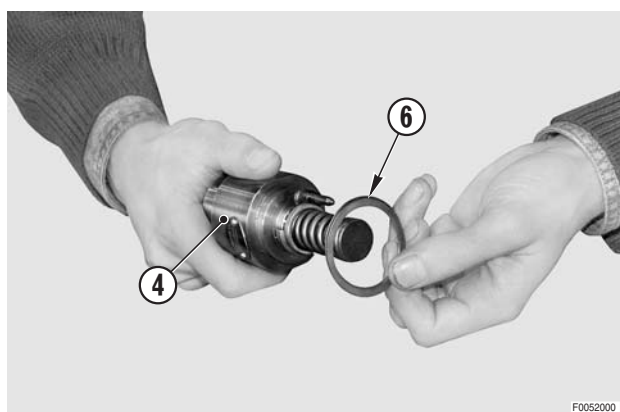
- 10 - Form a shim pack of thickness **"S"** (6).

- 11 - Apply a thin layer of sealant between the shims (6), the pump (4) and the engine block (7).

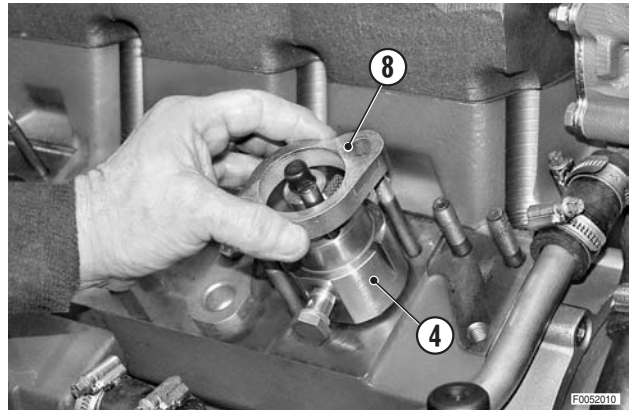
 Shims: Silastic 738



- 12 - Fit the shim pack (6) on the injection pump (4).




- 13 - Fit the pump (4), positioning it so that the pin of the pump control lever engages the recess in the control rod.
- 14 - Fit the locking collar (8).
- ★ The chamfer on the centre hole must be facing towards the pump.




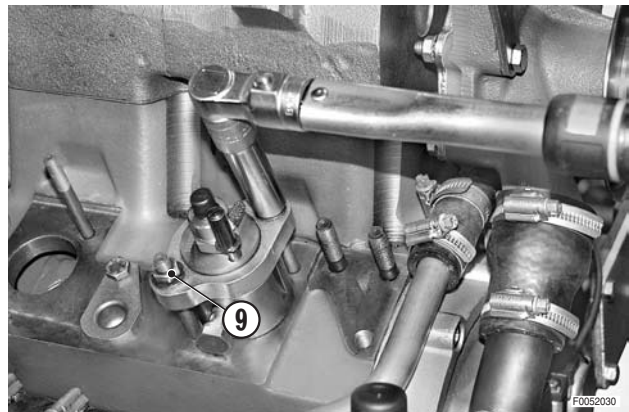
- 15 - Turn the camshaft clockwise to bring the roller to the closed period of the cam.
- ★ This period starts when plunger comes to the end of its downward stroke.
- 16 - Fit the washers and nuts (9); tighten them gradually in a crosswise sequence to bring the pump up against the crankcase.
- Tighten the nuts initially to a torque of 5 Nm (3.68 lb.ft.).
- ★ While tightening the nuts, gently rotate the pump in a clockwise direction in order to ensure that it stays in contact with the control rod.



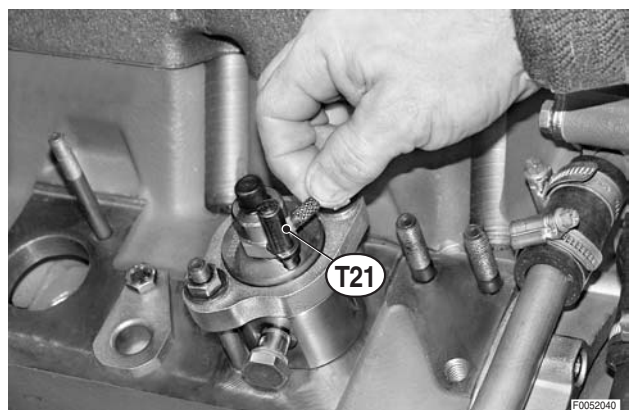
- 17 - Using a torque wrench, tighten the two nuts (9) alternately in two stages.

 Stage 1, Nuts: 10 Nm (7.37 lb.ft.)

 Stage 2, Nuts: 16 ± 4 Nm (11.8 ± 3 lb.ft.)

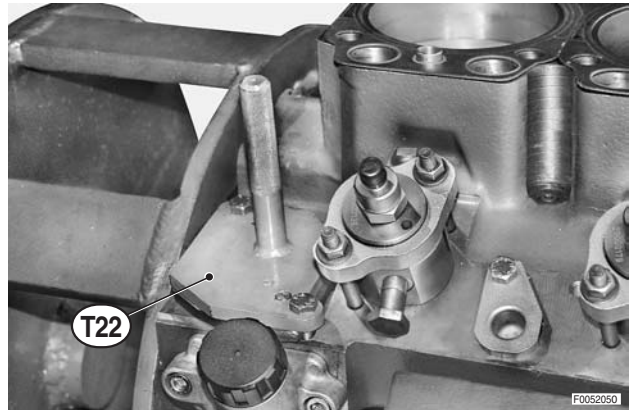


- 18 - Remove the pin **T21** (code 5.9030.951.0).
- 19 - Repeat the operation on all the remaining cylinders.

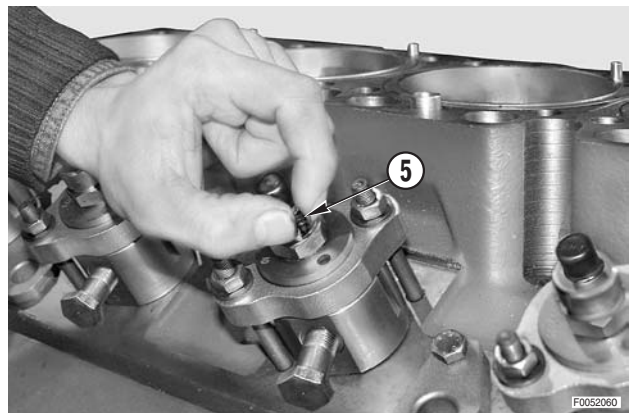




- 20 - Remove the tool **T22** (part no. 5.9030.960.0 for mechanical regulator – part no. 5.9030.959.0 for electronic regulator) and check that the control rod slides freely without sticking.

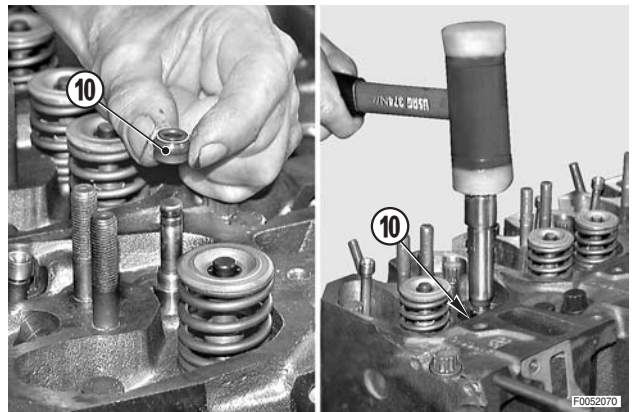


- 21 - Insert rubber plugs (5) in the open holes of the pumps.



- 22 - Return piston N° 1 to TDC, remove the tool **T19** (code 5.9030.615.0) complete with the gauges, and refit the valve stem seal (10) and the inlet valve spring previously removed for the valve timing operation.

- ★ To fit the valve stem seal, use a suitable drift and a soft faced mallet.
- ★ Take care not to damage the seal.





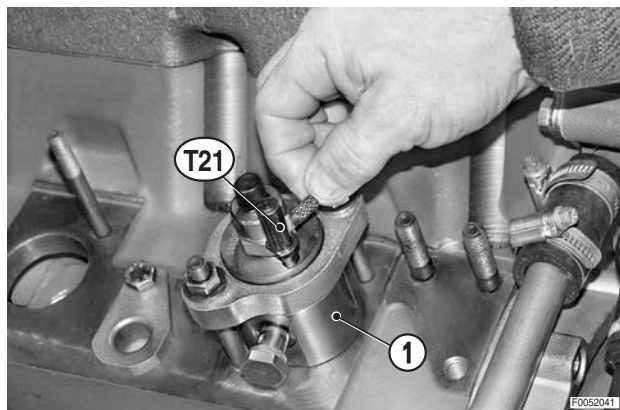
### 28.1 Removal and refitting an injection pump for testing

★ This procedure only applies in cases where no components are renewed and the calibration is not adjusted.

- 1 - Remove the rubber plug and lock the pump to be removed with the pin **T21** (code 5.9030.951.0).

★ To center the pin, move the control rod manually.

- 2 - Remove the pump (1), leaving the shim pack in position.



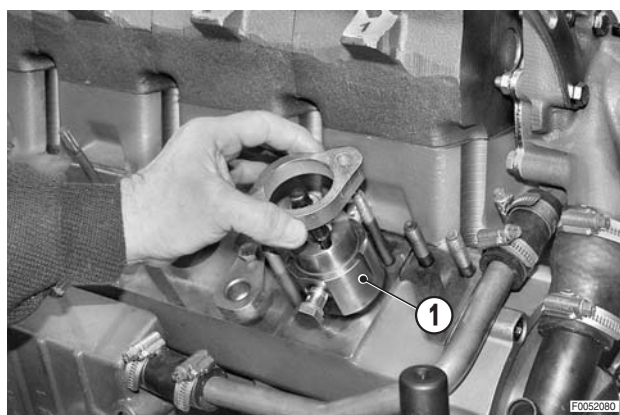
- 3 - After testing, apply sealant to the underside of the pump, fit the pump and tighten down with the retaining nuts.



Pump: Silastic 738



Nuts: 16 ± 4 Nm (11.8 ± 3 lb.ft.)



### 28.2 Renewal of an injection pump



Pumps must only be replaced with units of the same type (see «TECHNICAL DATA»).

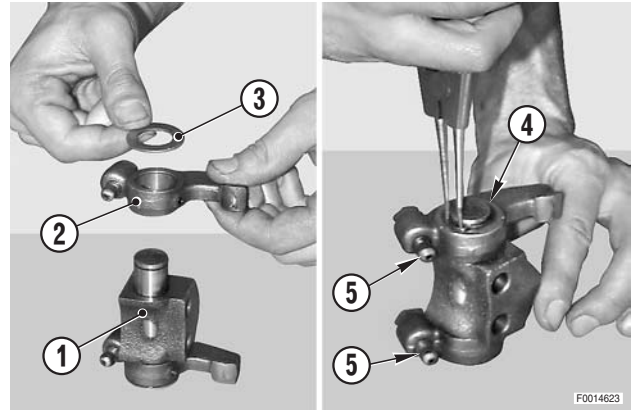
- 1 - Proceed as indicated in point 28.1 using the shims of the old pump.

### 28.3 Removal and refitting of an injection pump after renewing parts or calibration adjustment.


- 1 - An injection pump that has been overhauled and tested on the test unit must be installed as indicated in paragraph 28.2.

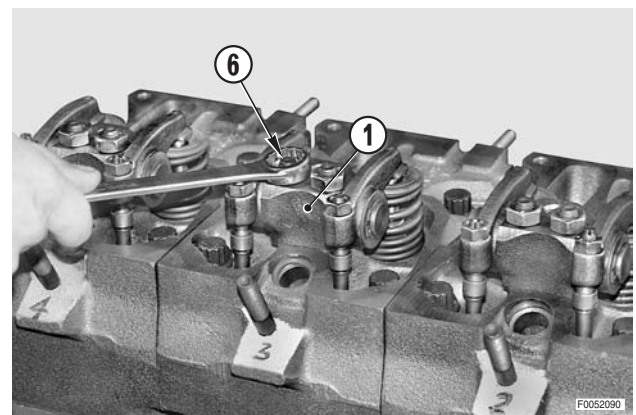
## 29. REFITTING THE ROCKER ASSEMBLIES

- 1 - Re-assemble the rockers by fitting the rocker arms (2), thrust washers (3) and circlips (4) to the support pivots (1).
- 2 - Loosen off completely the valve clearance adjuster screws (5).

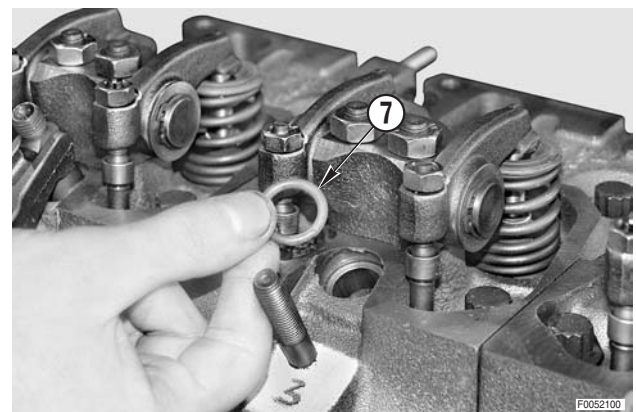


- 3 - Lubricate the pivot pins and fit the complete rocker supports.
- 4 - Fix the supports with nuts (6).

 Nuts 39 Nm (28.7 lb.ft.)



- 5 - Insert new injector O-ring seals (7) in the cylinder heads.
- 6 - Adjust the valve clearances following the procedure given below.



## 30. ADJUSTMENT OF VALVE CLEARANCES - INJECTOR ASSEMBLY

### 30.1 Valve clearance adjustment

**!** The procedure described below refers to cylinder N° 1; however the same procedure is to be repeated on all the cylinders in the sequence of the firing order.

- 1 - Turn the crankshaft clockwise to bring the piston of cylinder N° 1 to TDC at the beginning of its power stroke (inlet and exhaust valves closed).

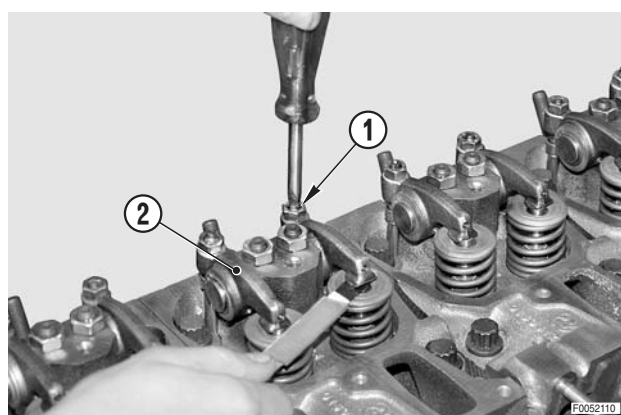
N° of CYLINDERS	FIRING ORDER
3	1-3-2
4	1-3-4-2
6	1-5-3-6-2-4

- 2 - Using a feeler gauge, turn the rocker adjuster screw (1) of the inlet valve (2) to obtain the prescribed clearance.

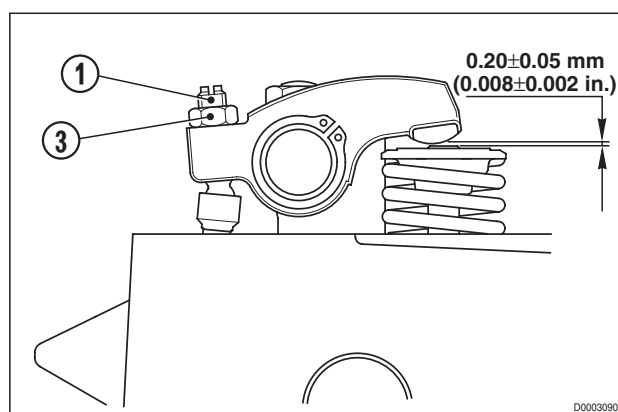
★ Clearance:  $0.20 \pm 0.05$  mm ( $0.008 \pm 0.002$  in.)

- 3 - Repeat the same procedure to adjust the clearance of the exhaust valve.

★ Clearance:  $0.20 \pm 0.05$  mm ( $0.008 \pm 0.002$  in.)



- 4 - After adjustment, hold the screws (1) in position and tighten the lock nuts (3).



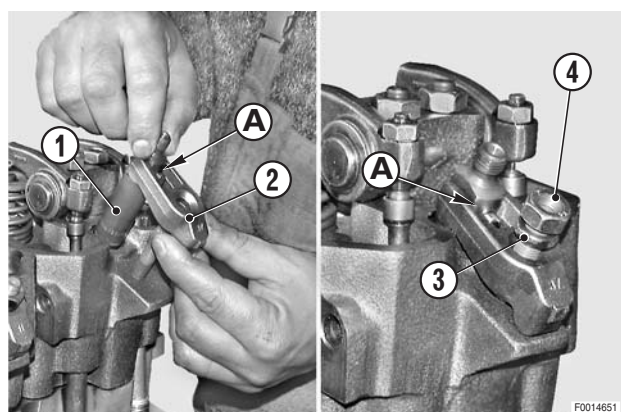
### 30.2 Injector assembly

- 1 - Fit the injector (1), the retaining bracket (2), the tapered washer (3) and the nut (4).

★ The face "A" of the injector must be facing the mounting bracket.

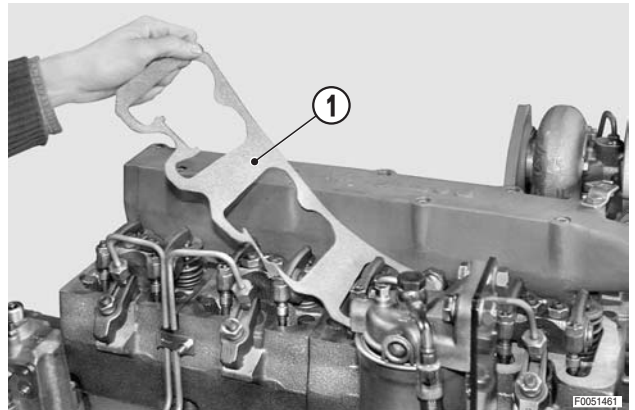
- 2 - Tighten the nut (4) securing the retaining bracket (2).

 Nut: 39 Nm (28.7 lb.ft.)




## 31. FINAL ENGINE ASSEMBLY OPERATIONS

- 1 - Fit the rocker cover gaskets (1).

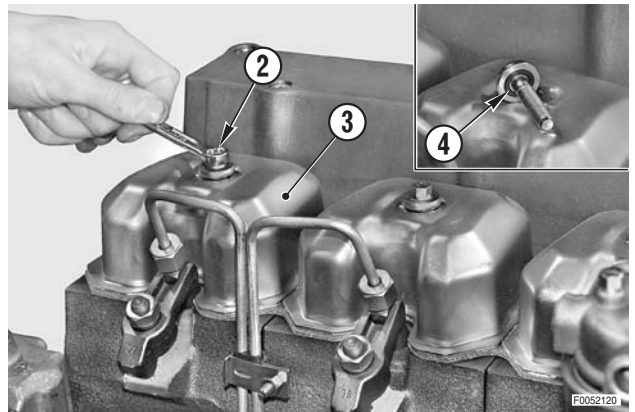


### 3- and 4-cylinder versions

- 2 - Fit the individual rocker covers (3) and secure with bolts (2).


 Bolts: 5 Nm (3.7 lb.ft.)

- ★ Check the condition of the O-ring seals (4) on the securing screws.

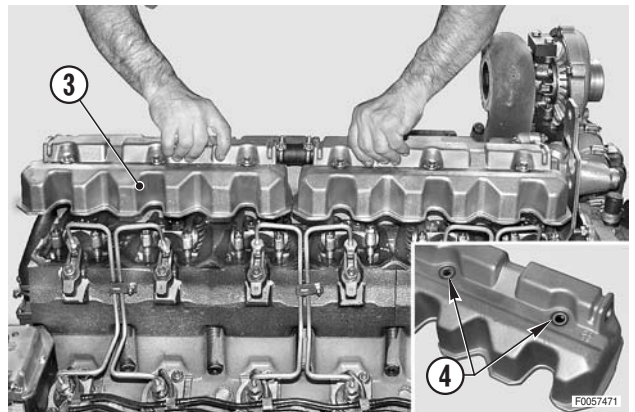


### 6-cylinder versions

- 2a - Fit the rocker covers (3) and tighten down with the bolts.


 Screws:  $10 \pm 1.5$  Nm ( $7.4 \pm 1.1$  lb.ft.)

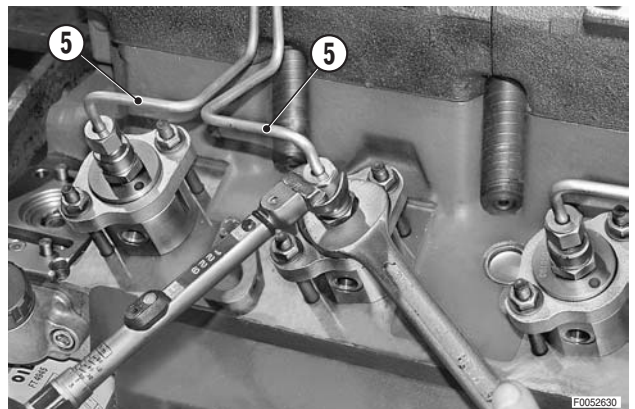
- ★ Check the condition of the O-rings (4) of the retaining screws.  
★ Tighten the bolts gradually in a crosswise sequence.



- 3 - Fit the fuel lines (5) to the injectors complete with the vibration damping bracket.

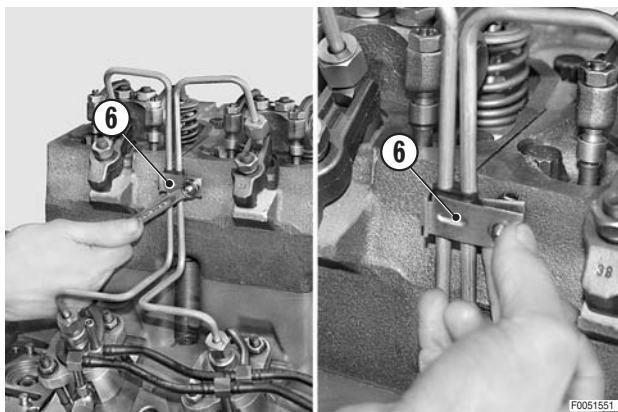
- ★ Hold the fitting on the pump stationary while turning the fitting on the pipe.

 Nuts:  $25 \pm 5$  Nm ( $18.4 \pm 3.7$  lb.ft.)



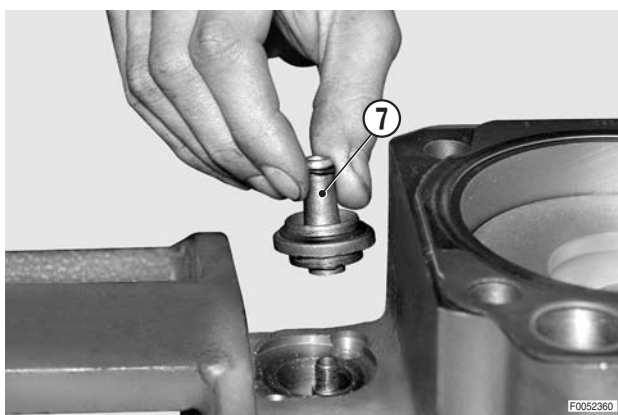


- 4 - Secure the vibration damping straps (6).



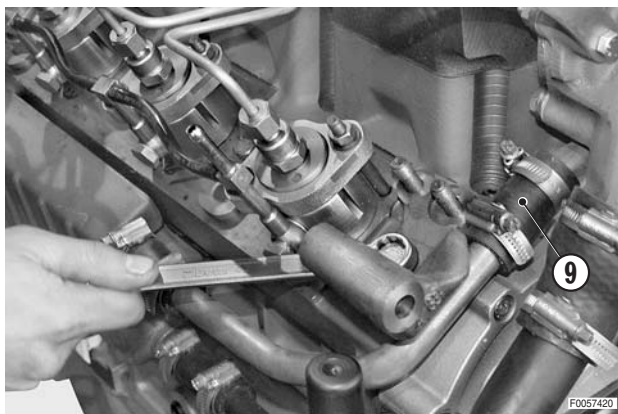
### 3/4-cylinder versions

- 5 - Install the oil drain fitting (7) for the blow-by device.

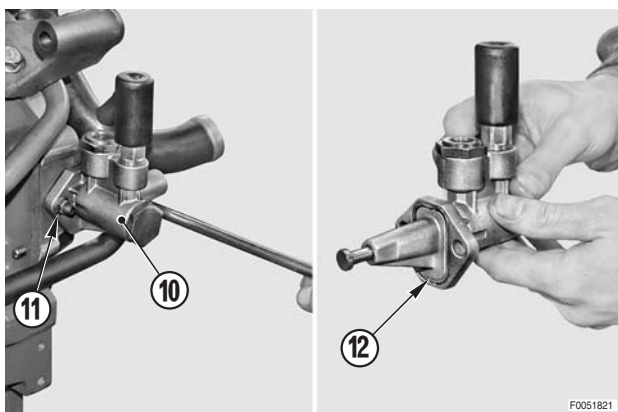


### All versions

- 6 - Fit the alternator pivot mounting (9) and secure with the relative screws and washers.




- 7 - Fit the fuel lift pump (10) and secure it with the nuts (11).  
★ Check that the O-ring (12) is present and that it is in good condition.



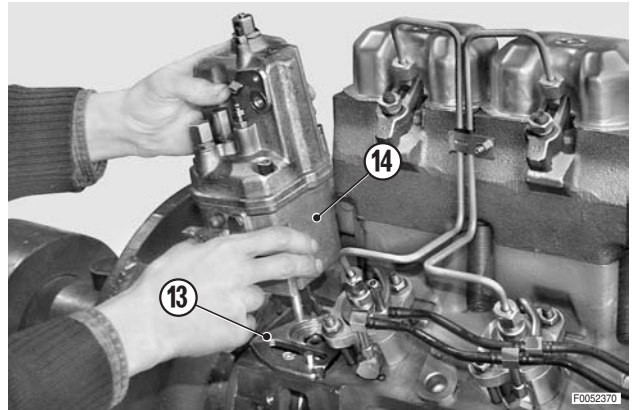


**Version with mechanical governor**

- 8 - Apply sealant to the contact surfaces of the gasket (13).


 Gasket: Silastic 738

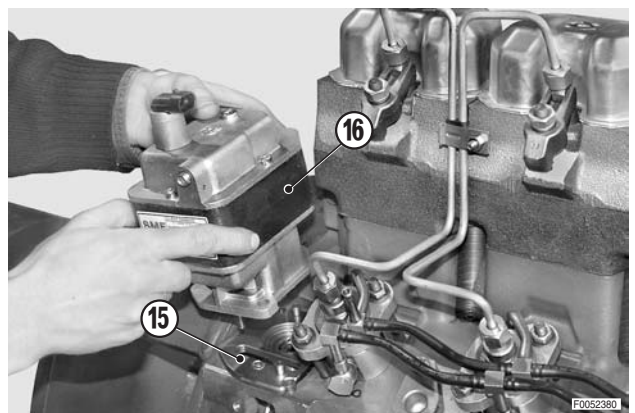
Position the gasket (13) and fit the mechanical governor (14)

**Version with electronic actuator**

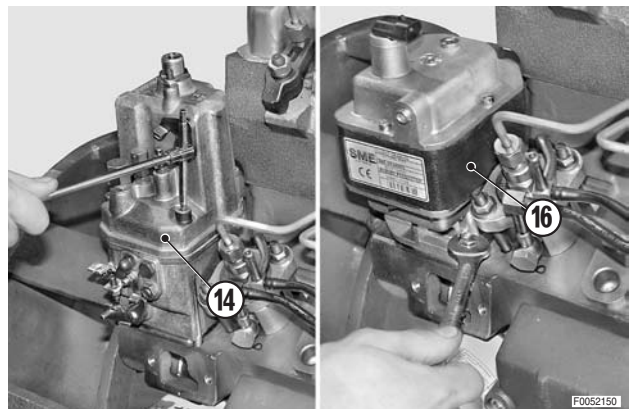
- 8a- Apply sealant to the surfaces of the gasket (15).  
Position the gasket and fit the actuator (16).

 Gasket: Silastic 738

 Using a screwdriver inserted through window "A", move the control rod so as to engage the drive shaft in the linkage plate.

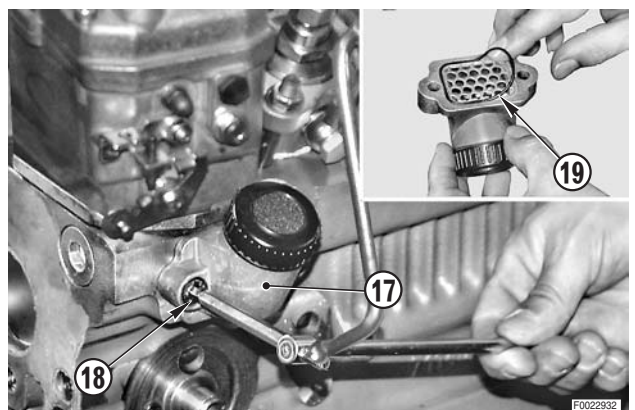


- 9 - Fix the mechanical governor (14) or actuator (16) tightening the bolts gradually in an alternate sequence.



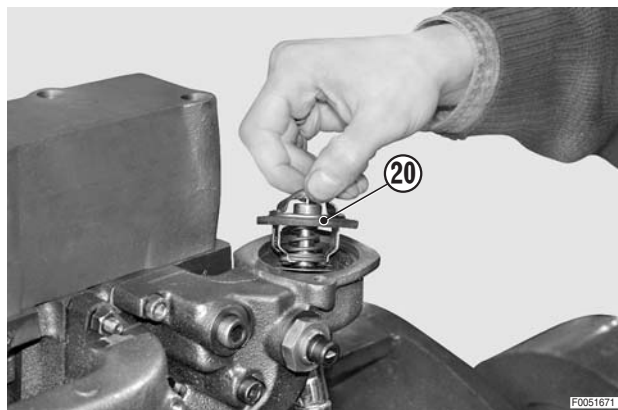
- 10 - Fit the oil filler (17) or the inspection window cover; fix with the screws (18).

★ Check the presence and condition of the O-ring (19) on the oil filler or the cover gasket.

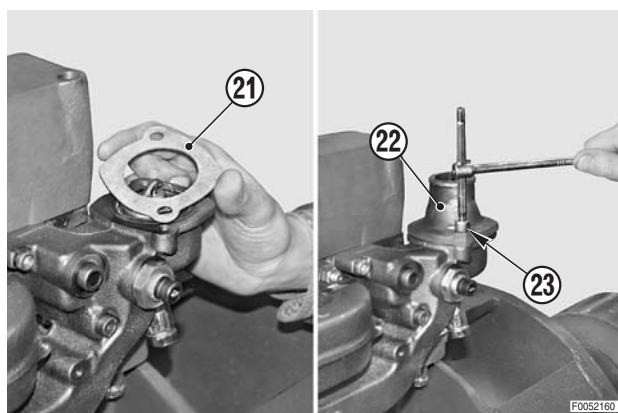


**3- and 4-cylinder versions**

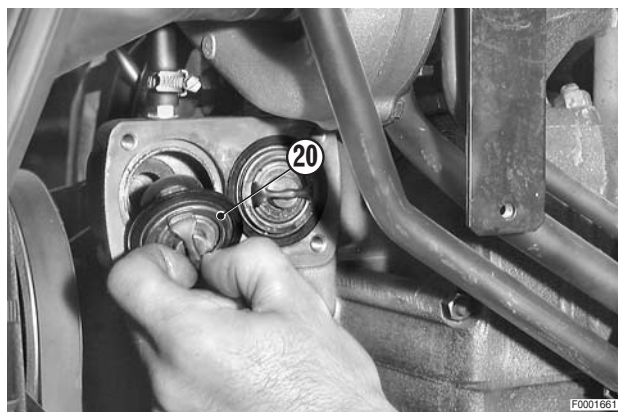
11 - Fit the thermostat (20).



12 - Fit the gasket (21) and the cover (22), fixing it with the bolts (23).

**6-cylinder version**

13 - Fit the thermostats (20).

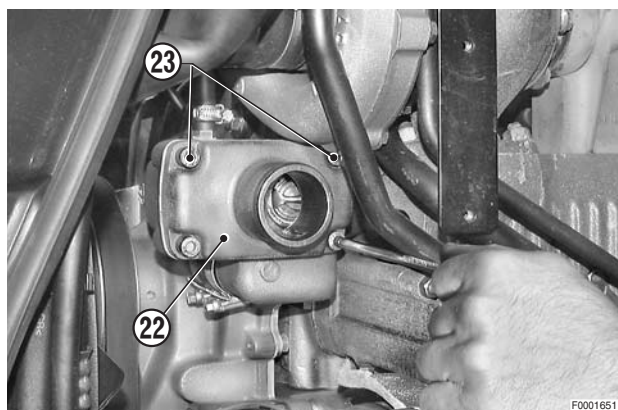


14 - Apply sealant to the cover contact surfaces.


 Cover: Loctite 510

16 - Fit the cover (22) and secure with bolts (23).

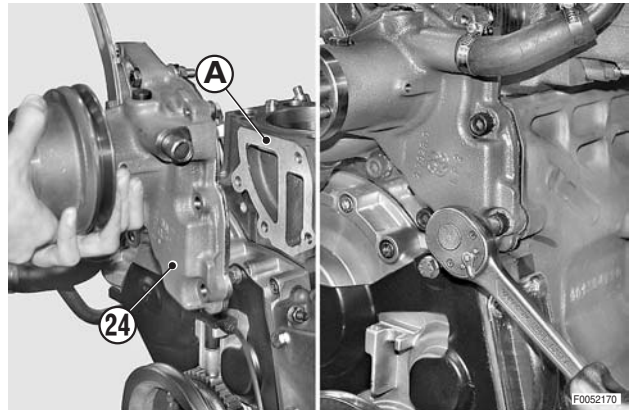
★ Tighten the bolts in a crosswise sequence.



- 16 - Position a new gasket "A" and fit the coolant pump (24).


 Pump fixing bolts: 49–54 Nm (36–40 lb.ft.)

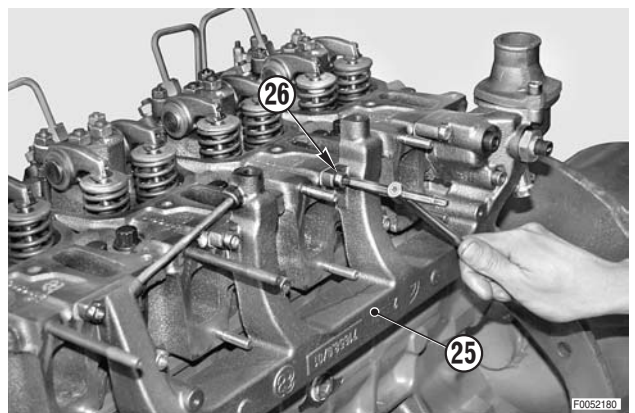
- ★ If the pump is to be renewed, check the alignment between the crankshaft pulley and the pump pulley.  
(For details, see the workshop manual for the vehicle in question).



### 3/4-cylinder version

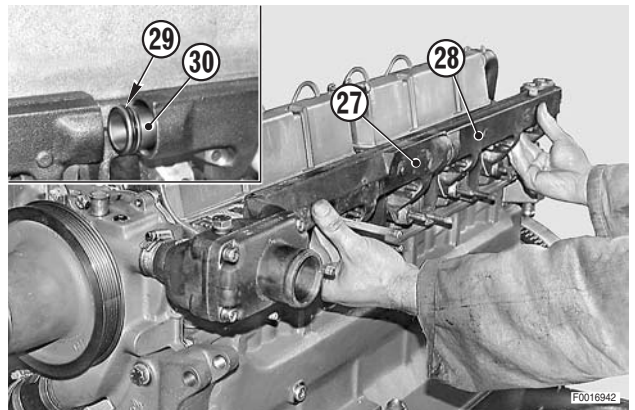
- 17 - Position the new gaskets and fit the manifolds (25) complete with thermostat and fix with bolts (32).

 Nuts:  $30 \pm 5$  Nm ( $22.1 \pm 3.7$  lb.ft.)



### 6-cylinder version

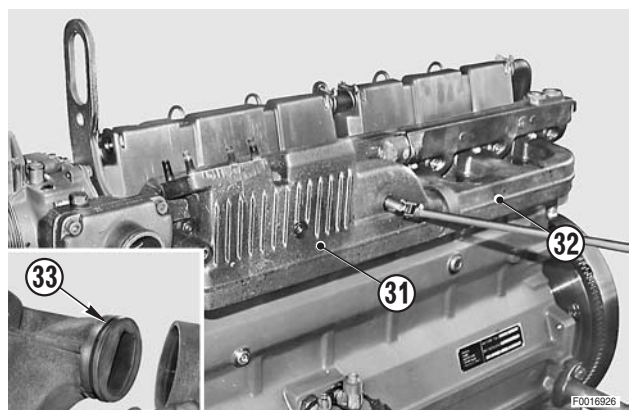
- 18 - Fit the hose (30) complete with O-rings (29) between the cooling circuit manifolds (27) and (28).



### 6-cylinder version

- 19 - Position the new gaskets (31); join the exhaust manifolds (32), fit them and secure with the nuts and spring washers.

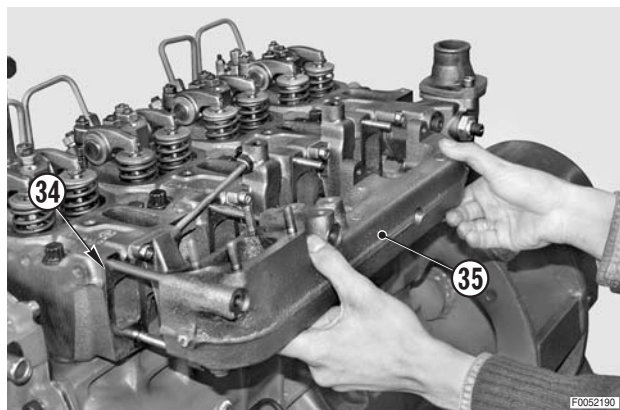
- ★ Carefully inspect the seal (33) at the joint between the manifolds.



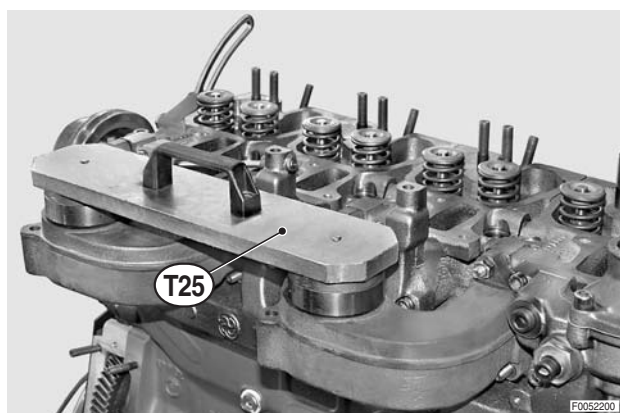


**4-cylinder version**


- 20 - Position the new gaskets (34) fit the exhaust manifold (35).

**4-cylinder version with twin exhausts**

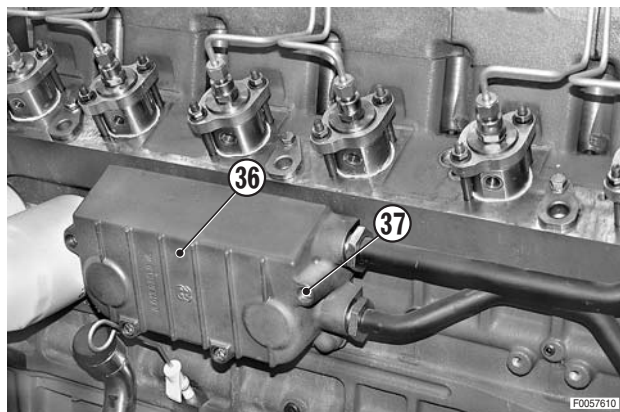
- 21 - Before tightening down the exhausts, apply the spacer tool **T25** (code 5.9030.952.0).

**For 4- and 6-cylinder engines only**

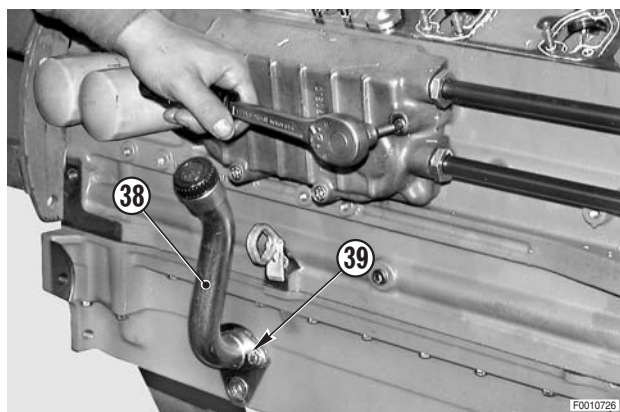
- 22 - Fit the O-rings and install the heat exchanger (36). Fix with the bolts (37).

 Bolts: 30±5 Nm (22.1 ±3.7 lb.ft.)

- 23 - Connect the pipes to the coolant pump and tighten the fittings and hose clamps.

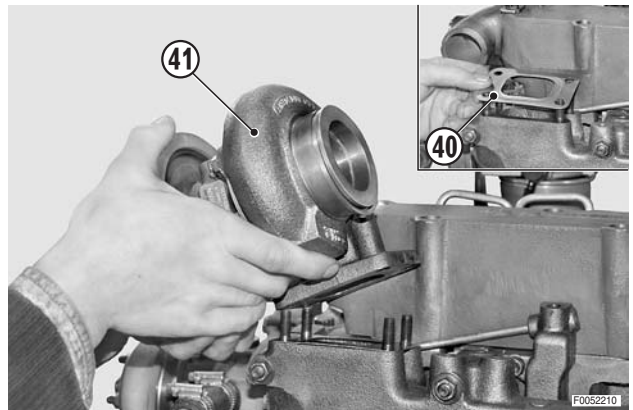
**For certain versions only**

- 24 - Fit the O-ring to the engine oil filler pipe (38); fix the filler pipe using the bolts (39) and the washers.



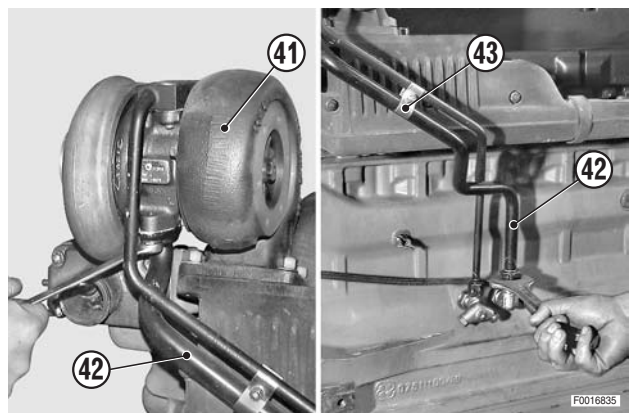
**WT-WTI version**

- 25 - Position the gasket (40) and fit the turbocharger (41), fixing it with the washers and nuts.



- 26 - Fit the new gasket and connect the lower lube oil drain pipe (42) to the turbocharger (41); connect the pipe to the fitting on the engine block.

★ Partially tighten the clamp (43).

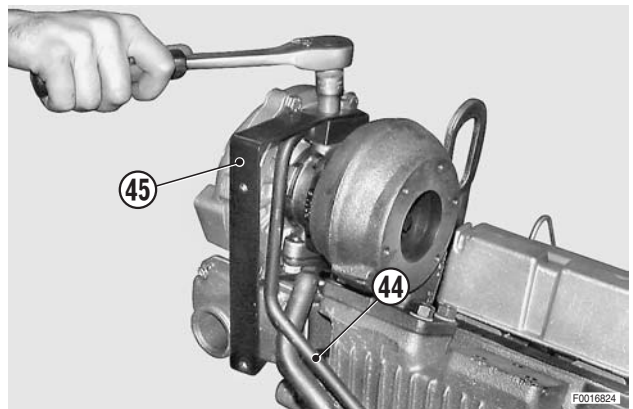


- 27 - Pour approximately 50 cc of engine into the turbocharger through the oil delivery port.

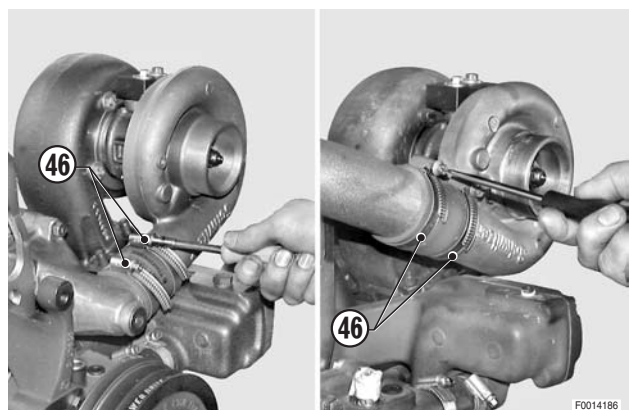
★ This oil is to ensure that the turbocharger is adequately lubricated when the engine is first started.

- 28 - Fit the new gasket and position the lube oil delivery pipe (44) and, only on some versions, fit the bracket (45) for the left-hand side cover.

- 29 - Connect the pipe (44) to the fitting on the engine block and tighten the clamp (43).

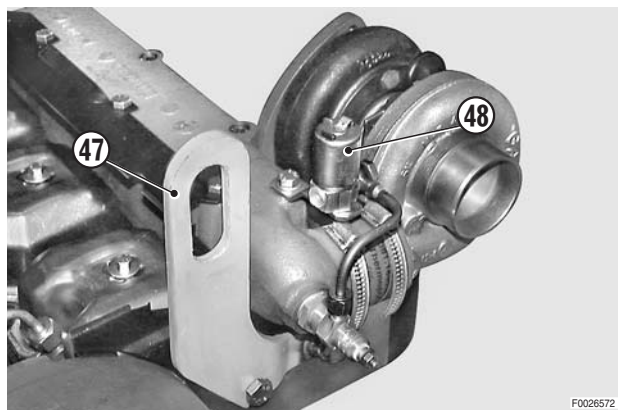


- 30 - Connect the intake hose and secure with the clamps (46).






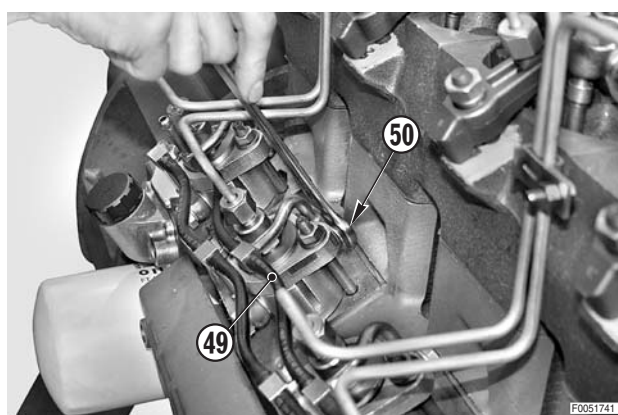
- 31 - Fit the engine lifting hook (47) and, where appropriate, the thermostarter solenoid valve (48).



- 32 - Fit the fuel return pipe (49) and secure with fitting (50) and the relative seals.

**!** The gaskets must be renewed on reassembly; only fit Same original parts code 2.1569.213.0.


 Pipe fittings:  $20 \pm 4$  Nm ( $14.74 \pm 3$  lb.ft.)

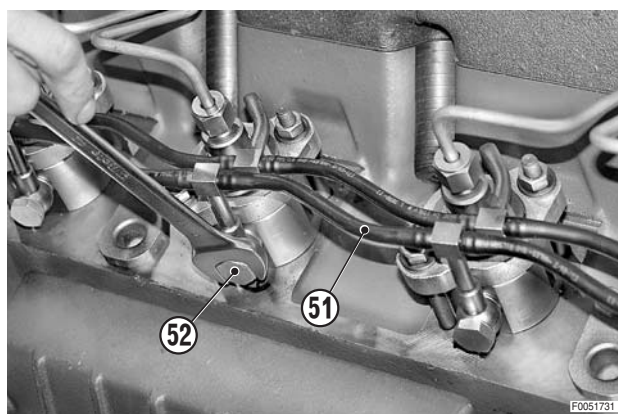


- 33 - Fit the fuel delivery pipe (51) and secure with the fitting (52) and the relative seals.

**!** 1 - The gaskets must be renewed on reassembly; only fit Same original parts code 2.1569.213.0.


2 - If the fittings are damaged, replace with SAME original parts code 2.3249.093.2

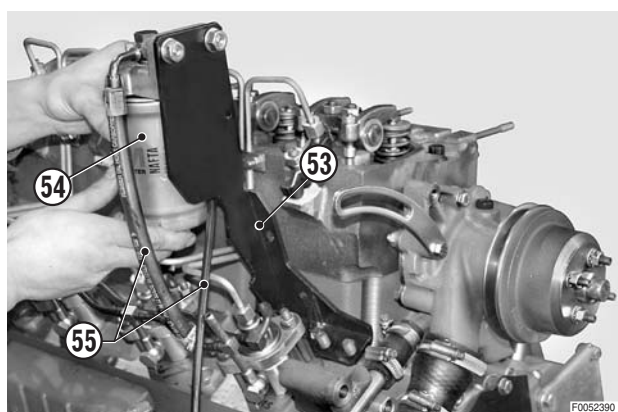
 Pipe fittings:  $20 \pm 4$  Nm ( $14.74 \pm 3$  lb.ft.)



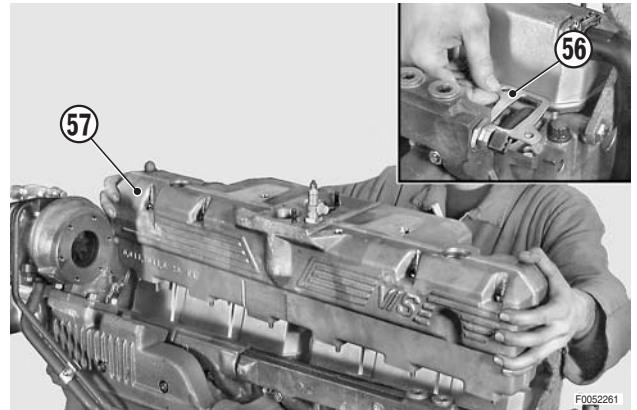
### For certain versions only

- 34 - Fit the bracket (53) complete with fuel filters (54) and connect the pipes (55).

 Pipe fittings: max.  $45 \pm 2$  Nm ( $33.2 \pm 1.5$  lb.ft.)



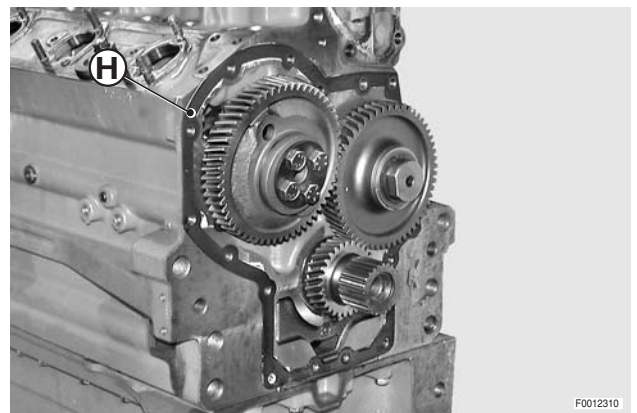
35 - Fit the gaskets (56) and fit the complete manifold (57).



### For all engines

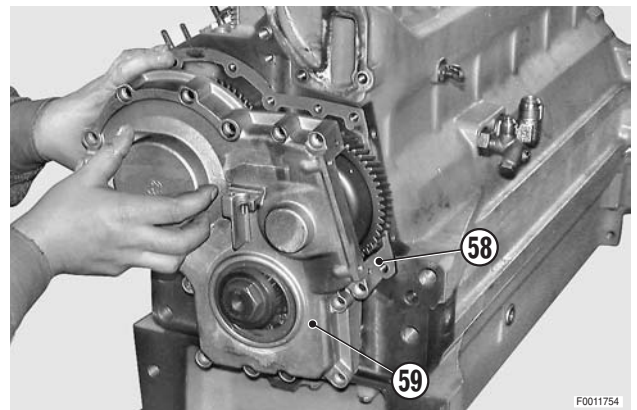
36 - Apply sealant to the contact surfaces in zones “H” of the timing cover.

 Surfaces: Silastic 738



37 - Position the gasket (58) and fit the timing cover (59), holding it in position with the relative fixing bolts and washers.

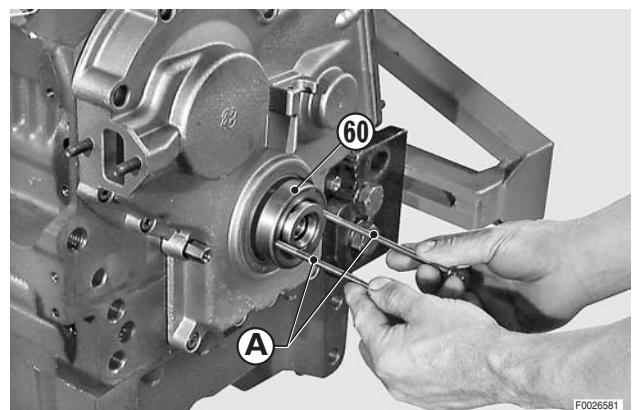
★ Do not tighten the bolts at this stage.



### 3- and 4-cylinder versions

38 - Lubricate the lips of the oil seal and fit the spacer (60).

★ Use two screws “A” to drive it home.

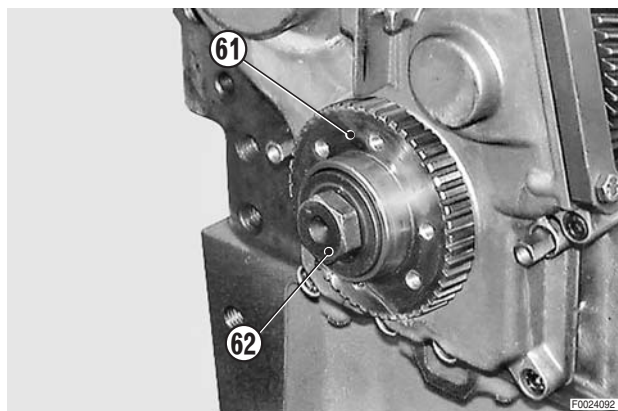


**6-cylinder versions**

39a - Lubricate the lips of the oil seal and fit the pulley hub or the pulse wheel (61).

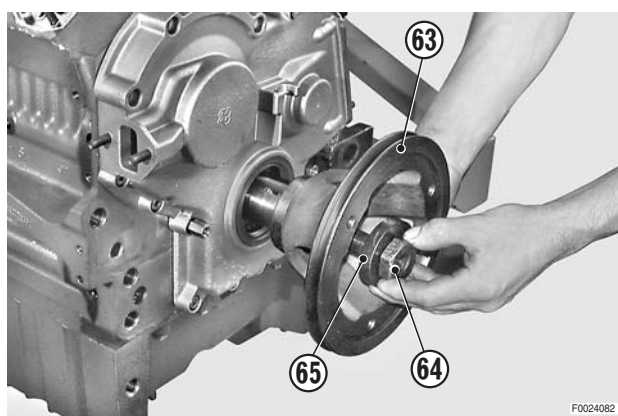
★ Do not fit the key.

39b - Secure the pulley hub or the pulse wheel (61) with the bolt (62) and washer tightened to a torque of approx. 30 Nm (22.1 lb.ft.).

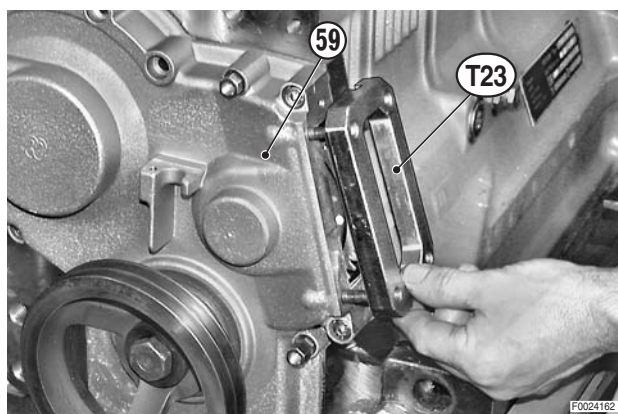
**3- and 4-cylinder versions**

40 - Temporarily fit the crankshaft pulley (63) and fix it with the bolt (64) and washer (65) tightened to a torque of approximately 30 Nm (22.1 lb.ft.).


★ Do not fit the key.



41 - Fit tool **T23** (code 5.9030.634.0) between the timing cover (59) and the engine block; tighten the locking screws to align the contact surfaces.

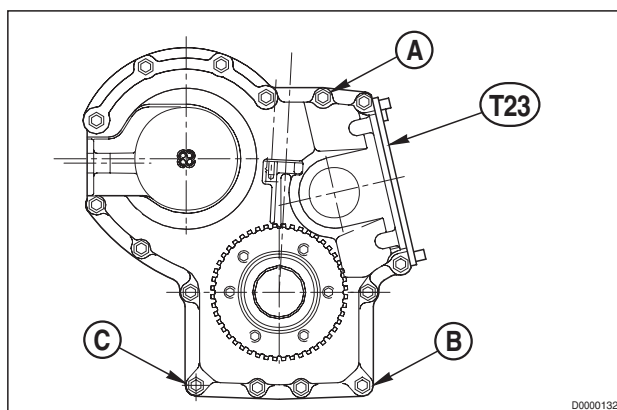


42 - Tighten the bolts in the following sequence **A-B-C**.

 Bolts: 24.5 Nm (18 lb.ft)

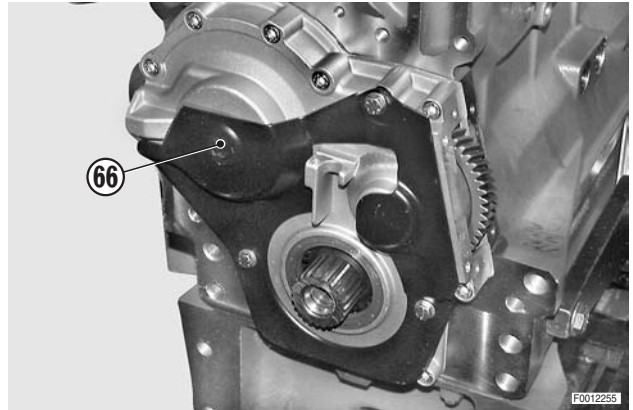
43 - Tighten the other bolts in a triangular sequence to the same torque.

44 - Remove tool **T23** (code 5.9030.634.0) and trim off the excess gasket through the gear housing.






- 45 - Remove the pulse wheel or the pulley and fit the cover (66).




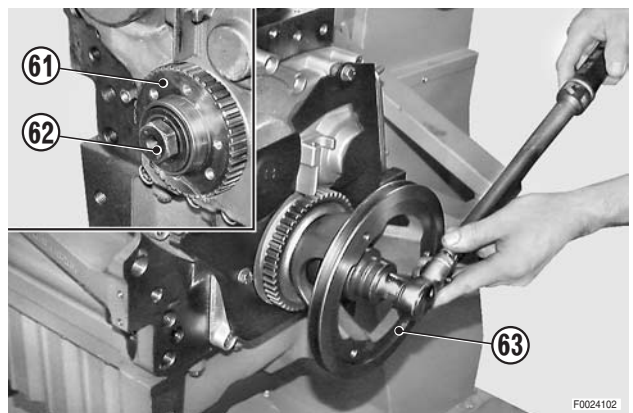
- 46 - Fit the drive key.  
Fit finally the crankshaft pulley (63) (for 3 and 4 cylinders) or the hub (61) (for 6 cylinders) and fix with bolt (62) and washer.

★ Lubricate the bolt, the washer and the threaded hole in the crankshaft.

 Bolt: engine oil

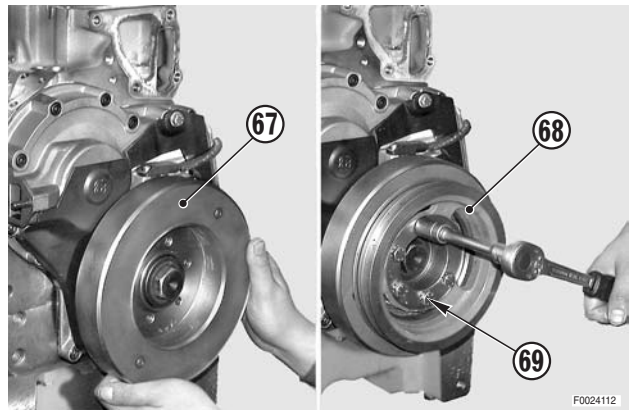
★ Tighten the bolt in two stages:

 1st tightening: 60–70 Nm (44.2–51.6 lb.ft.)  
2nd tightening: 326–350 Nm (240–258 lb.ft.)

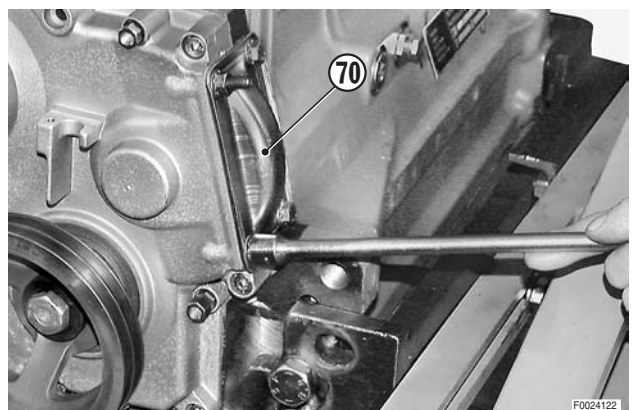


### 6-cylinder version

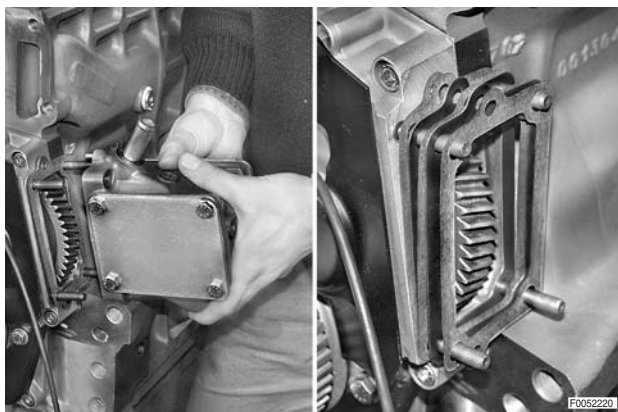
- 47 - Fit the shims, the vibration damper (67) and the crankshaft pulley (68); fix the pulley to the hub with the bolts (69) tightened to approx. 30 Nm (22.1 lb.ft.).



- 48 - Fit the cover (70) of the supplementary power take-off complete with gaskets.




- !** If the tractor is equipped with a compressor for trailer air braking, or an auxiliary power take-off, this operation is to be replaced with the relative installation operations after determining the necessary shim thicknesses.



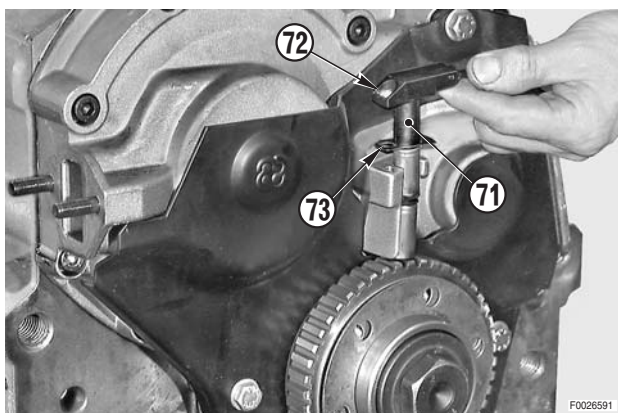
### Only when required

- 49 - Fit the engine speed pick-up (71) and fix with the bolt (72), the spring washer and the flat washer.

 Bolt: Loctite 242

 Bolt: 6 Nm (4.4 lb.ft.)

- ★ Check that the distance between the pickup and the pulse wheel is 0.35–0.75 mm (0.014 – 0.029 in.). If the distance between the pickup and wheel is not within these limits, add shims (73) between the cover and pickup to obtain the correct distance.

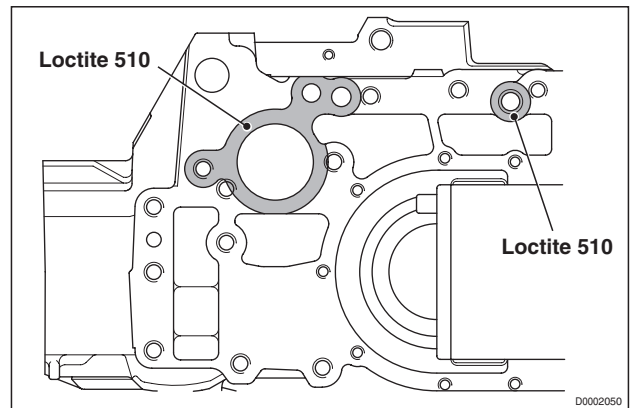





## 32. FINAL ENGINE ASSEMBLY - REAR END

- 1 - Apply sealant to the contact surfaces of the block around the threaded plugs and the camshaft hole.

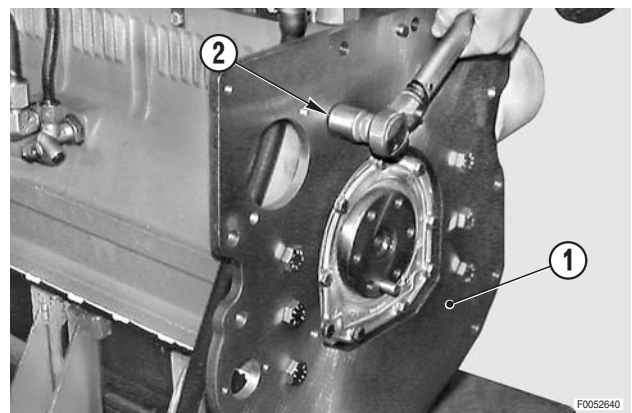
 Surfaces: Loctite 510



- 2 - Fit the flange (1) and fix with bolts (2).

 Bolts: 120 Nm (88.4 lb.ft.)

- ★ Tighten the bolts gradually in a crosswise sequence.

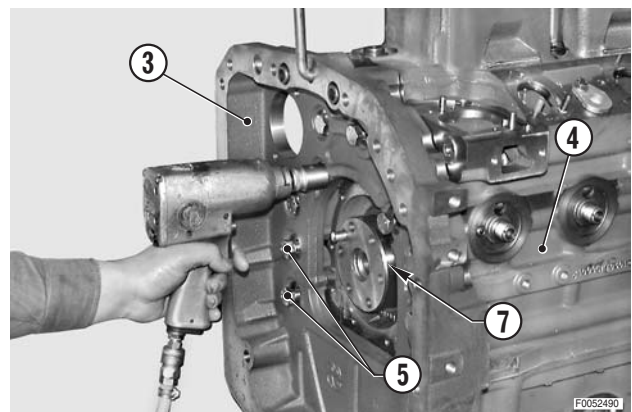


### 6-cylinder version

- 2a - Connect the flywheel housing flange (3) to a hoist and fit it to the engine block (4).  
Fix with bolts (5).


 Bolts: 120 Nm (88.4 lb.ft.)

- ★ Tighten the bolts gradually in a crosswise sequence.

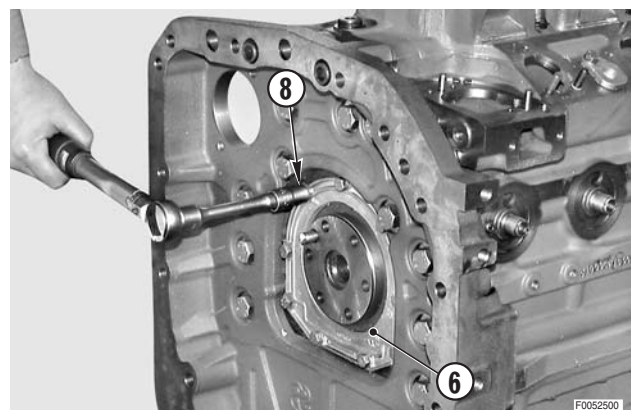


- 3 - Position the new gasket (7) on the rear oil seal carrier (6).

- 4 - Lubricate the lips of the oil seal and fit the carrier using bolts (8).


 Bolts: 24.5 Nm (18 lb.ft.)

- ★ Tighten the bolts progressively in a cross-wise sequence.

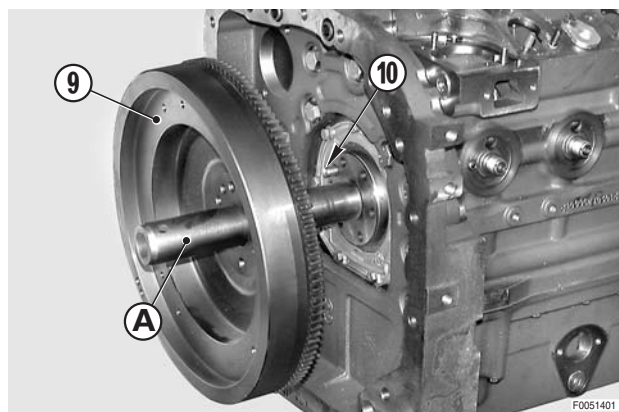


5 - Screw dowel "A" into the central hole of the crankshaft.

6 - Lubricate the bolt threads.


 Bolts: Engine oil


7 - Fit the flywheel (9) so that it locates on the dowel (10).

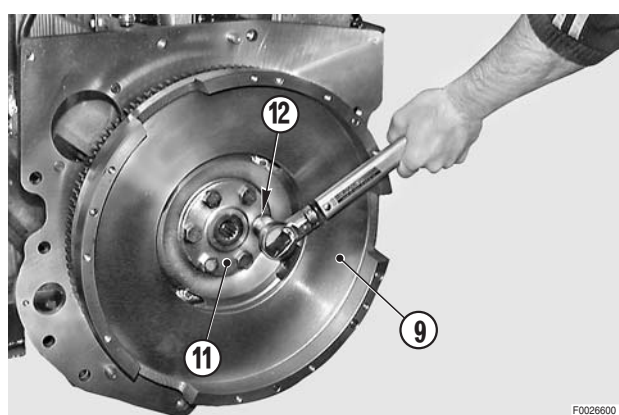


### Only where fitted

8 - Fit the flywheel retaining flange (11) and fix the flange and flywheel with the bolts (12) (lubricated).

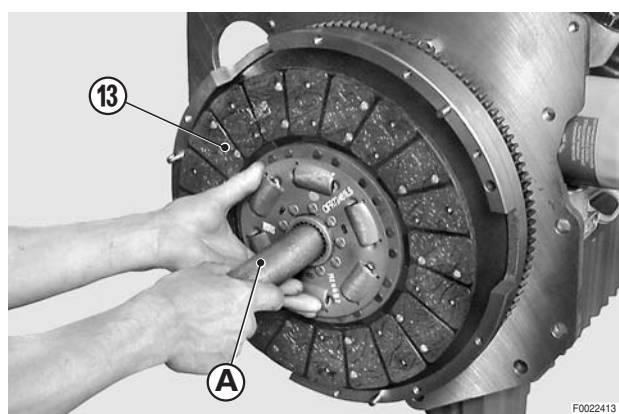
 Bolts: engine oil

 Bolts: 108 Nm (79.6 lb.ft.)



### For certain versions only

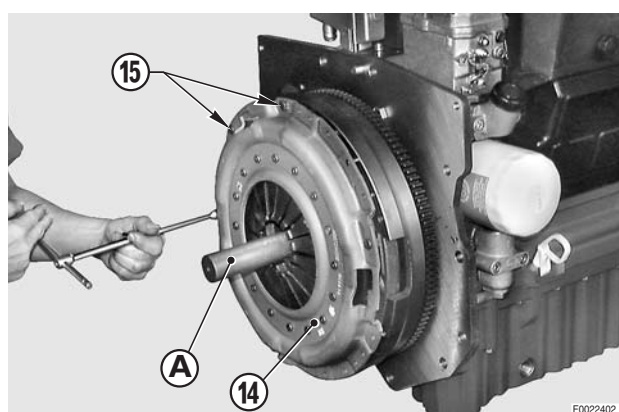
9 - Screw the locating dowel "A" into the crankshaft and fit the clutch plate (13).



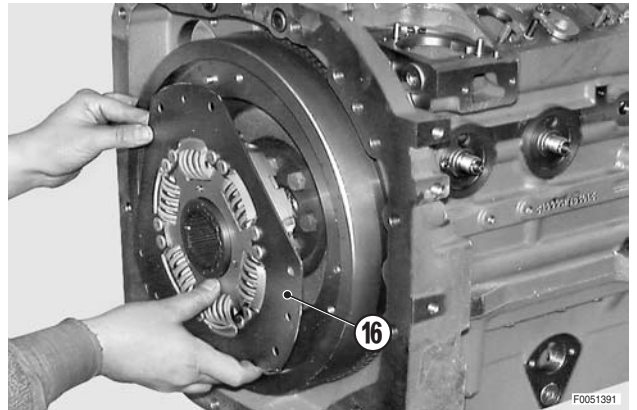
10 - Fit the pressure plate assembly (14) and fix it with the bolts (15).

★ Tighten the bolts gradually in a crosswise sequence.


11 - Remove the dowel "A".

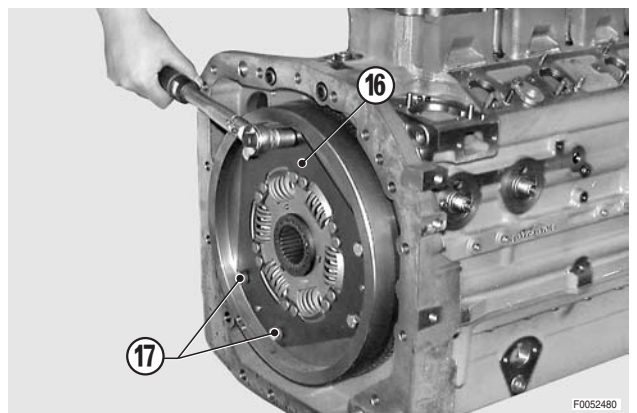


- 9 - Fit the spring coupling (16), centering it on the locating dowels of the flywheel.

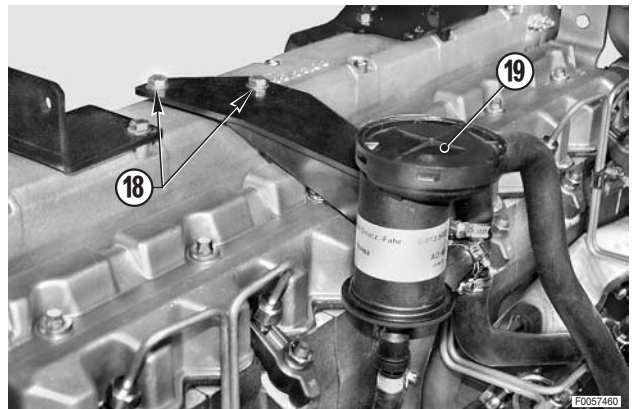


- 10 - Insert the spring coupling (16) retaining bolts (17) and toothed washers and tighten down.

 Bolts: 50 Nm (36.8 lb.ft.)



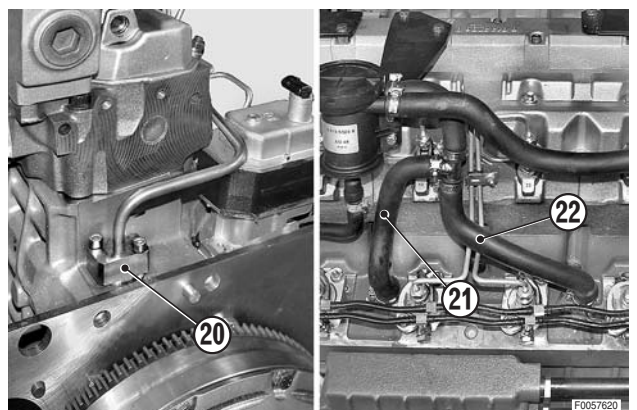
- 11 - Position the blow-by group (19) complete with pipes and secure with screws (18).



- 12 - Fix the oil recovery flange (20).

★ Fit the new O-ring

- 13 - Connect the vapour recovery pipes (21) and (22) and secure them with the clamps.



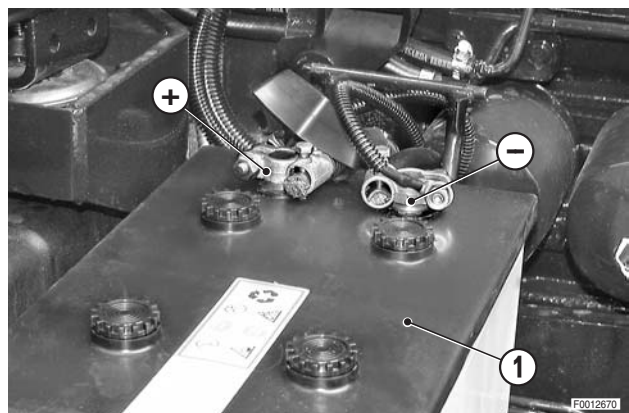


### 33. ENGINE TESTS

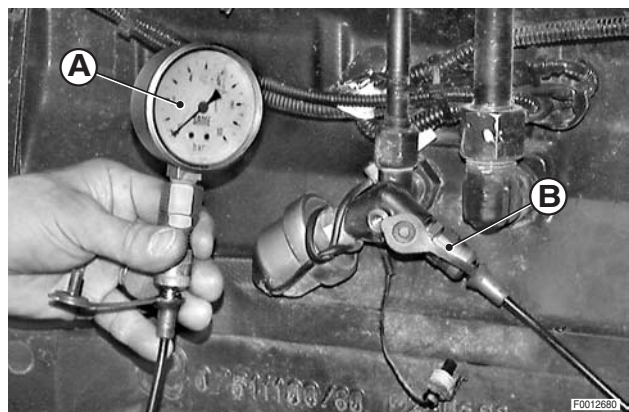
- ★ These tests are necessary for the final setup of the fuel injection system and to check the efficiency of the engine lubrication system.  
The tests are to be carried out after the engine has been installed on the tractor and after all the liquid levels have been restored (engine oil, coolant, fuel and re-charging of the air conditioning system).

#### 33.1 Initial start-up and oil pressure check

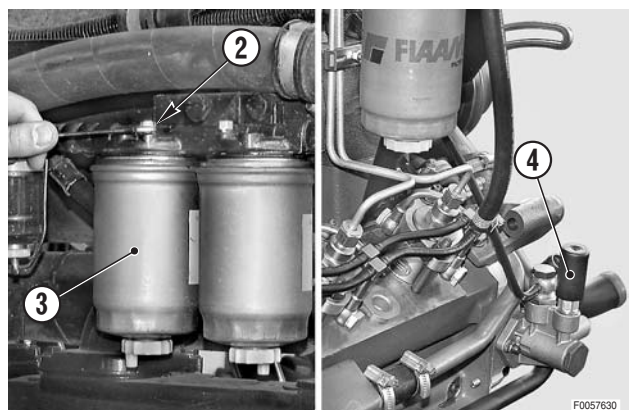
- 1 - Check that the battery is fully charged and then connect the terminals.
  - ★ First connect the positive terminal (+) and then the negative (-).



- 2 - Disconnect and remove the engine oil pressure sensor and connect a 10 bar pressure gauge "A" to a pressure test fitting "B".
  - ★ Note that in this condition, the oil pressure warning light will not illuminate when the electrical circuits are powered on.



- 3 - Loosen the drain plug (2) on the fuel filter (3) and operate the fuel lift pump (4) until the fuel flowing out of the drain hole is free of air bubbles. Tighten the plug (2).
  - ★ If no resistance is encountered when operating the lever of the fuel lift pump and no fuel flow is obtained, turn the starter key briefly back and forth until the fuel starts to flow.
- 4 - Run the engine at idle speed and check that pressure gauge (fitted in step 2) shows a reading of 0.5 – 1.5 bar (7.25 – 21.75 psi).



- 5 - Leave the engine idling for about 5 minutes, and then, using the hand throttle, set an engine speed of about 1200 rpm to bring the engine up to its normal operating temperature (engine oil temperature above 50°C).
- 6 - Return the engine to idle speed and check that the oil pressure indicated on the pressure gauge is greater than 0.5 bar.
- 7 - Stop the engine, remove the pressure gauge and carry out the procedure to synchronize the injection pumps.

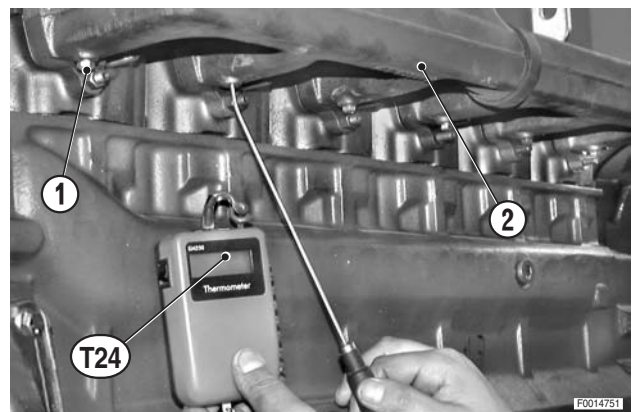
### 33.2 Synchronizing the injection pumps.

- ★ This procedure must be carried out:
  - a - After the removal of one or more pumps for testing, overhaul or renewal.
  - b - When the engine runs unevenly and when the engine operating parameters have been checked using the All Round Tester or (for industrial engines) with the electronic control unit.

**!** The following tests are to be carried out in a well-ventilated environment and with the exhaust pipe connected to a fume extraction system

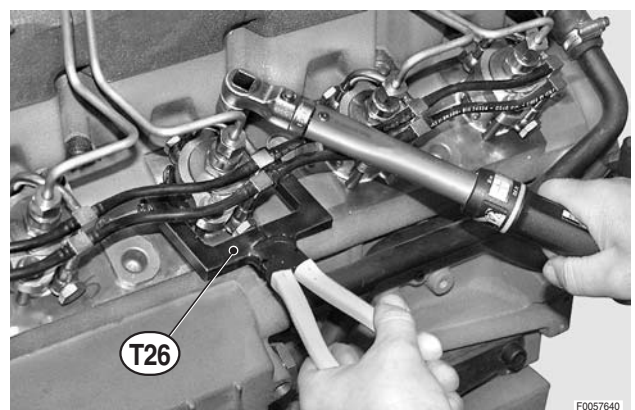
#### 33.2.1 Test

- 1 - Bring the engine to normal operating temperature and then leave it running at idle speed.
- 2 - Remove the plugs (1) from the lower part of the exhaust manifold (2).
- 3 - Insert the digital temperature probe **T24** (code 5.9030.667.4) in the manifold hole corresponding to cylinder n°1; allow the temperature reading to stabilise, then note down the value.
- 4 - Repeat the operation for all the cylinders.
- 5 - Check the temperature difference between all the cylinders; if the temperature difference is not within the optimum range of 15°C (59°F), it will be necessary to adjust the angular position of the injection pumps.



#### 33.2.2 Angular adjustment of the injection pumps

- 1 - With the engine running at idle speed, slightly loosen the retaining nuts (1) of the injection pump (2) to be adjusted.
  - ★ The nuts should be loosened sufficiently to eliminate the tightening torque but so that the pump is still held firmly.





3 - With the tool **T26** (code 5.9030.953.0) engaged in the slot "**A**" of the pump, rotate the pump.

★ Rotate the pump **CLOCKWISE** to **INCREASE** the temperature of the exhaust gases.

Rotate the pump **COUNTER-CLOCKWISE** to **REDUCE** the temperature of the exhaust gases.

**NOTE** - After adjusting the angular position of one pump, it will be necessary to re-check the exhaust gas temperature for all the cylinders.

4 - Using a torque wrench gradually tighten the pump retaining nuts (1) in an alternating sequence to the prescribed final torque.

For the procedure and data, see «28.TIMING THE INJECTION PUMPS».

